Materials in Design Engineering

FORMERLY MATERIALS & METHODS

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

October, 1957

Complete Contents—page 1

PRICE ONE DOLLAR

For more information, turn to Reader Service card, circle No. 459

Materials

in Design Engineering®

formerly Materials & Methods

Selection & use of metals, nonmetallics, forms, finishes

OCTOBER 1957 **VOL. 46, NO. 5**

PRICE $1.00 PER COPY, EXCEPT MID-SEPTEMBER ISSUE NOT SOLD SEPARATELY. PAYABLE IN ADVANCE, ONE YEAR, $3.00; TWO YEARS, $5.00 IN U. S. POSSESSIONS AND CANADA. IN ALL LATIN AMERICAN COUNTRIES: ONE YEAR, $10.00; TWO YEARS, $16.00. ALL OTHER COUNTRIES: ONE YEAR, $15.00; TWO YEARS, $25.00 (REMIT BY NEW YORK DRAFT). PUBLISHED MONTHLY, WITH AN ADDITIONAL ISSUE IN MID-SEPTEMBER. PRINTED BY PUBLISHERS PRINTING-ROGERS KELLOGG CORP. SECOND CLASS MAIL PRIVILEGE AUTHORIZED AT NEW YORK, N. Y. ADDITIONAL ENTRY AT BROOKLYN, N. Y. ALLOW TWO MONTHS FOR CHANGE OF ADDRESS.

Published by
REINHOLD PUBLISHING CORP.
430 Park Avenue
New York 22, N. Y.

This periodical is indexed regularly in the Engineering Index and the Industrial Arts Index

What's new IN MATERIALS

...AT A GLANCE

A NEW PRECIPITATION HARDENING STAINLESS STEEL is said to withstand the air friction heat (1000 F) developed in aircraft travelling at speeds of 2700 mph. The steel, containing 15 chromium, 7 nickel, 1.2 aluminum and 2.5% molybdenum, is easy to fabricate, low in cost and available in volume. Recommended for use as aircraft skins and structural parts, the stainless steel is made in all standard wrought forms. (More details next month.)

A SILICON IRON MAGNETIC SHEET, not yet commercially available, is said to have excellent magnetic properties in four directions. Key to successful production of the sheet is rigid control of the internal structure of the metal during all steps of processing. According to the producer, the magnetic sheet greatly increases the operating efficiency of transformers, generators and motors. (More details next month.)

A NEW TYPE POLYURETHANE RUBBER is described by the manufacturer as being "capable of outwearing any known rubber." The synthetic rubber is said to be completely oil and ozone resistant and can be stored indefinitely without deteriorating. Immediate uses are expected to be in valves, gaskets, hose, o-rings, oil seals, vibration absorbers and wire insulation.

IMPROVED MACHINABILITY OF COLD FINISHED STEEL BARS is said to result from small additions of copper. Tool life of the bars is reported to be 2½ times longer than the life of bars without copper. Tests show copper-containing steel bars also have good elasticity and corrosion resistance.

A RADIATION SENSITIVE GLASS can tell how many x-rays a person has received. Made by dissolving silver metal into a melt of high phosphate-content glass, the clear substance glows a bright orange when exposed to a large amount of x-rays. The glass is particularly useful as a detection device for persons working with nuclear materials.

BETTER HIGH TEMPERATURE ALLOYS may result from studies of meteorites. Since meteorites undergo rapid heating (up to several thousand degrees Fahrenheit) when they enter the earth's atmosphere,

scientists believe that microscopic inspection will reveal variations in the crystals of iron and nickel that make up the bulk of the meteorite. These crystal structure variations may indicate the pattern of heating that takes place in the meteorite.

A STRONG BOND BETWEEN POLYETHYLENE AND BRASS and polyethylene and rubber results with use of a new adhesive made of "partly hydrogenated polybutadiene." Peel strengths up to 100 lb per in. and tensile strengths of 1000 psi are possible with the adhesive. Bonding is accomplished by heating at 250 to 350 F and applying pressures of 100 psi or less. (More details next month.)

EXTRUDED MOLYBDENUM TUBING is now available in limited quantities. Made with a new extrusion process, the tubing has a tensile strength of 70,000 to 100,000 psi and a yield strength of 60,000 to 90,000 psi. The tubing measures less than 1 in. o.d., approximately 0.1 in. wall thickness, and 3 to 6 ft in length.

HIGH QUALITY VINYL EXTRUSIONS are possible with use of a new vinyl resin. The resin is said to have good physical and mechanical properties and can be used in high speed production equipment. It is being used as a covering for building, appliance and telephone wires, and as a material for garden hose and belting.

SEAMLESS STEEL CYLINDERS capable of holding gases and chemicals under pressures as high as 10,000 psi are now commercially available. The cylinders are made from white hot steel billets that are pierced to form hollow forgings under great pressure. The ends of the cylinders are hot formed by spinning, swaging or forging.

SHRINK RESISTANT WOOL is made by a new process involving the use of plastics. According to the U.S. Dept. of Agriculture, developer of the process, "Blends of polyamide and epoxy resins make possible shrinkage control of wool without loss of inherent quality and strength of the original fiber." One drawback: the resin treated wool "feels" stiffer than untreated wool.

NOBELIUM is the official name of the world's newest element, element 102. The new element was made by bombarding a thin film of curium on aluminum foil with 110 to 120-mev ions of carbon-13. It was discovered by a group of American, British and Swedish scientists.

AN EPOXY-BASE ADHESIVE "stays put" when applied to vertical surfaces. The adhesive, an aluminum filled epoxy resin, is used to bond metal, wood and glass to each other and to other materials. It is said to be water and oilproof, acid and alkali resistant, and nonflammable.

Turn to page 179 for more "What's New in Materials"

MATERIALS

Lifetime Spring

A cobalt-base metal spring placed in the heart of a person some 13 months ago has successfully functioned more than 38,000,000 times. The spring is compatible with human blood and tissue and is not affected by any of the body acids.

Honey of a Bloom

Plastics clover blossoms containing syrup are helping scientists to determine the best location for bee hives for both honey production and pollination. Equipment attached to the flower automatically records the amount of syrup gathered by the bees.

Strong Forward Wall

A new press box at the University of Michigan's football field has sandwich paneled walls made of anodized aluminum with a core of polystyrene foam. The press box stretches from one 24-yard line to the other.

Hot in a Hurry

A new electric resistance type furnace developed in Germany can reach a temperature of 6000 F in less than 6 min. The furnace can melt samples of pure tungsten in 5 min and can liquefy crystals of zirconium oxide in about 3 min.

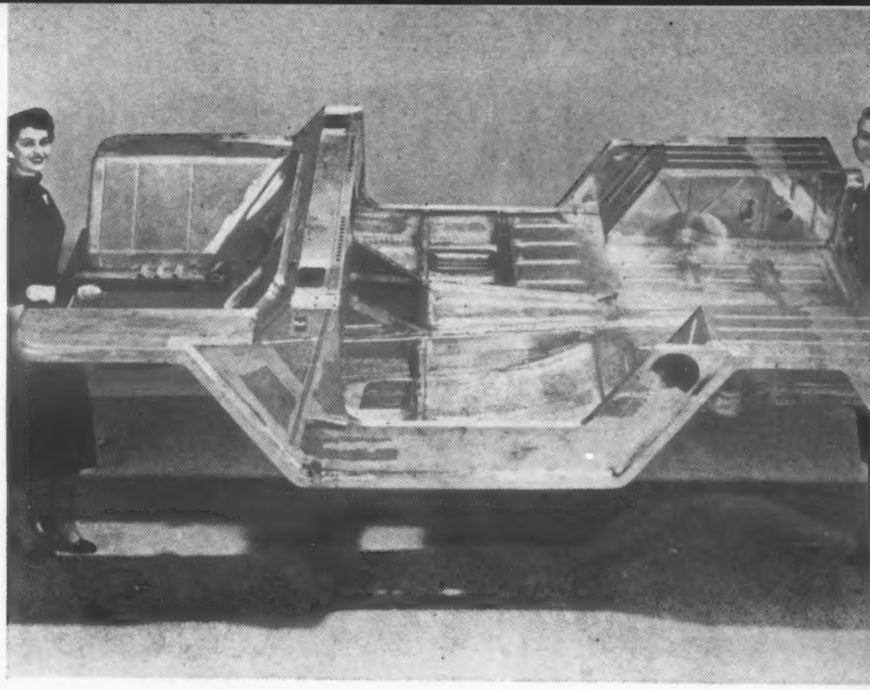
Bogus Bones

Authentic-looking plastics hearts, hands, feet, skulls and complete skeletons are being made out of polyester resins. The plastics skeletons do not nick and break as real bones do and can be marked with crayon for demonstration purposes.

For more information, turn to Reader Service card, circle No. 590

MATERIALS AT WORK

New and interesting applications of engineering materials



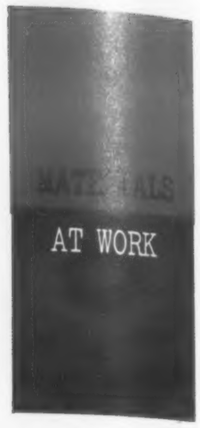
Kaiser Aluminum & Chemical Corp.

One-piece aluminum truck frame is light, strong, economical

The automotive industry's first all-aluminum unitized vehicle body is being produced by Ford Motor Co. for a new line of military trucks.

The entire aluminum integral body and frame structure weighs only 134 lb (see top photo) and is spot welded throughout (below). Wheel base is 85 in. and over-all length is 132 in. The vehicle, a four-wheel drive utility unit, provides room for four passengers and cargo, and is claimed to be "lighter, stronger, more economical to operate and better performing than any comparable military truck."

U.S. Rubber Co.



Plastic replaces copper for sewage filter pipe

The replacement of copper pipe by a modified styrene resin has eliminated a serious corrosion problem in Chicago's Sanitary District sewage treatment system.

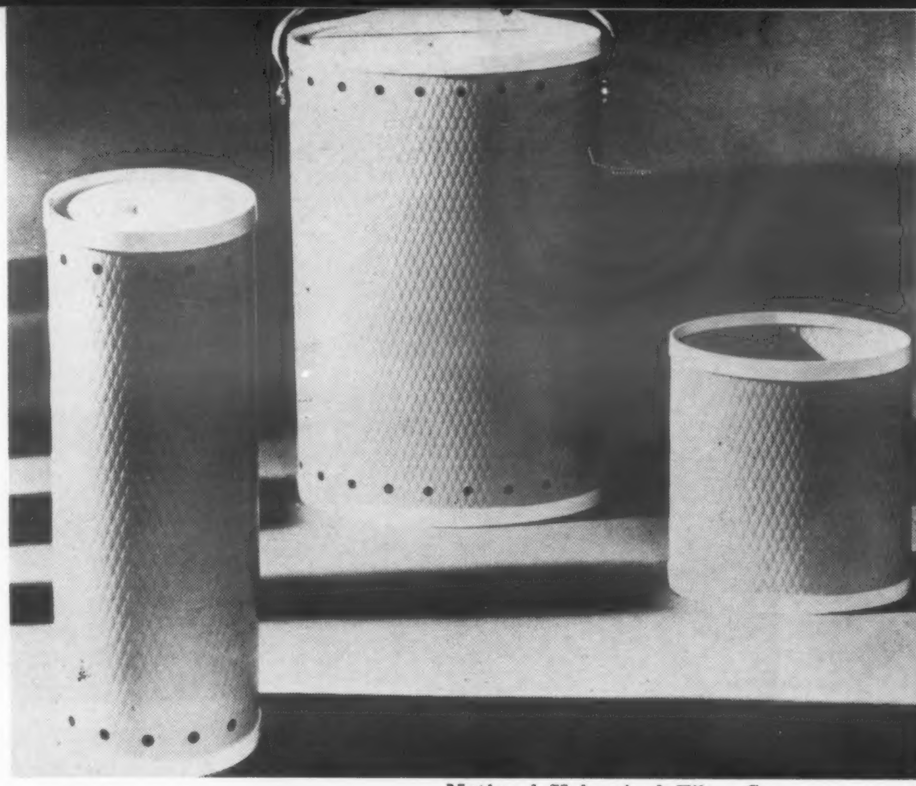
The piping, made of a terpolymer composed of styrene-acrylonitrile-butadiene, is used in the interiors of 98 rotary filters similar to the one shown here. Each filter, 16 ft long and 11½ ft in dia, contains 820 ft of the 1-in. pipe, as well as several hundred drainage nozzles, lock nuts, division strips and fittings. The piping has been in operation at room temperature and 30-in. maximum vacuum-type pressure since 1948 and has not shown any leaks or other damage.

Armco Steel Corp.

'Fishing' problem solved with stainless valve

The switch from a high alloy nonferrous metal to 17-4PH stainless steel for valves used in underground oil well operations has eliminated the necessity for frequent replacement due to damage. The nonferrous valve (shown at the right in photo) could not take the severe battering and high stresses encountered when grappling tools "fished" the valve to the surface. The 17-4PH stainless steel (left) was found to have proper hardness, strength and corrosion resistance.

Fibre sheet is embossed to give . . .



National Vulcanized Fibre Co.

. . . attractive pattern for baskets.

Embossing gives vulcanized fibre eye-appeal and strength

An embossing technique for vulcanized fibre which not only produces three-dimensional designs but which increases its structural strength, is paving the way toward more extensive use of this material.

In addition to its light weight and strength—it is half the weight of aluminum and 90% as strong—embossed vulcanized fibre can be polished to a high natural finish or decorated with standard paints, varnishes, lacquers or vinyl finishes without prior treating. Its most extensive application is for such things as re-usable packing and shipping containers, clothes hampers and waste baskets (see photo above right), and machine and electrical housings.

Aluminum curtain wall is functional, decorative

Exactly 2950 aluminum panels weighing a total of 800,000 lb will make up the world's largest aluminum curtain wall when the Tishman Realty Co., Inc. completes the 38-story office building shown here. The panels, fabricated by Reynolds Metals Co., are first anodized to provide a protective finish. Small pyramids are then die-pressed by a specially developed 1700-ton press. A typical panel and window unit is approximately 7 ft, 5 in. wide and 11 ft high, and weighs about 225 lb.

MATERIALS AT WORK

1—*Longitudinal sections are made by laying up reinforced plastics over foamed cores.*

Lightweight, strength, fire resistance are combined in . . .

Glass-Reinforced Plastics Patrol Boat

2—*Nearly completed boat. Note compound curves and beveled surfaces.*

With the successful launching of a new speed boat, reinforced plastics has taken another step forward in its bid for use as a structural material in the design of large sections. The glass-reinforced polyester resin boat, constructed by Universal Moulded Products Corp., is 40 ft, 2 in. long, has a 12-ft beam and weighs 19,000 lb fully equipped. It is claimed to be one of the largest and fastest for its size ever built of reinforced plastics and will be used by the U.S. Navy as a leader and patrol boat to supervise the activities of larger landing craft.

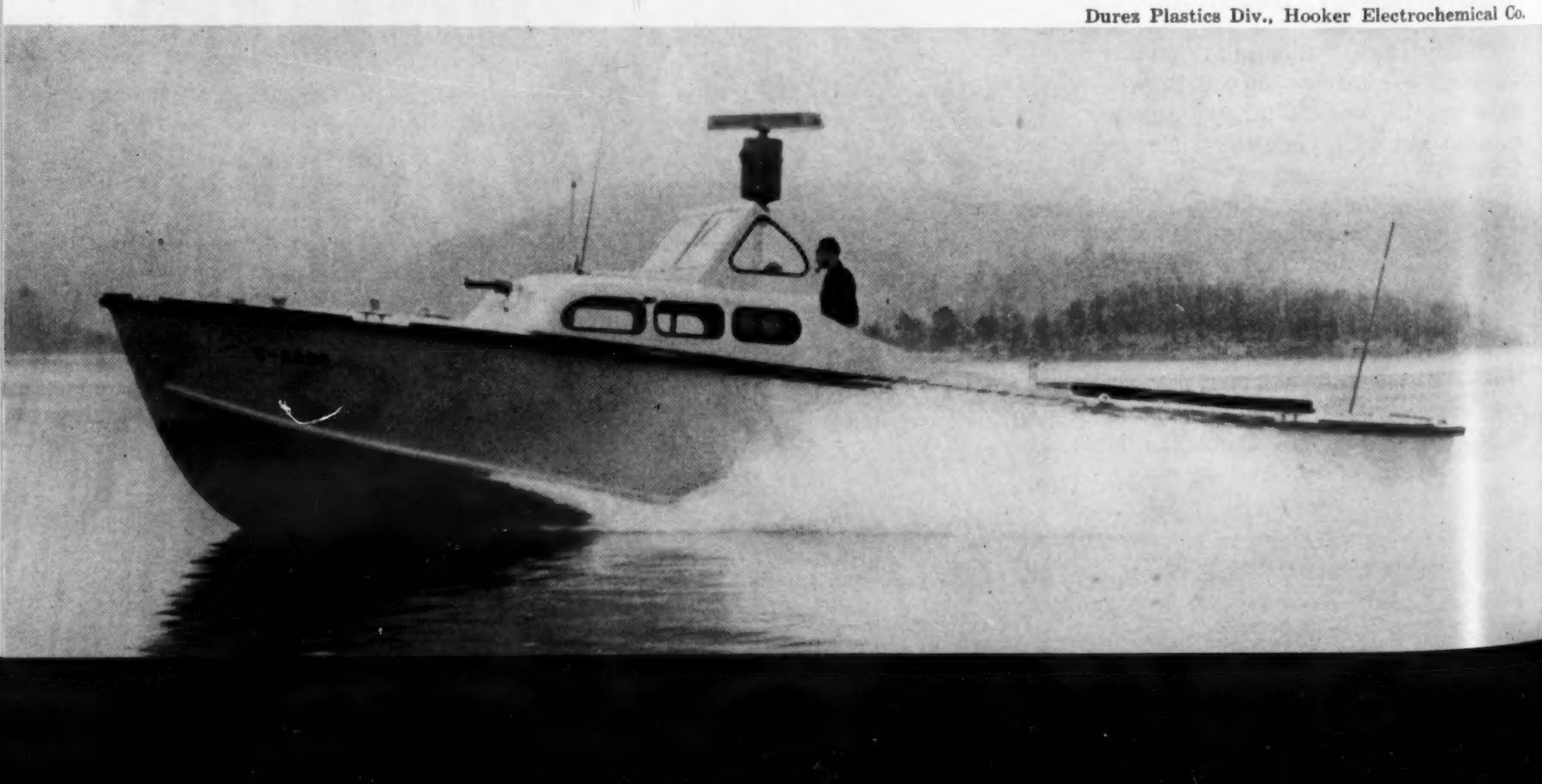
How it was built

The basic hull is a single-skin, transversely-framed unit made in

(continued on p 236)

3—*Completed boat on trial run.*

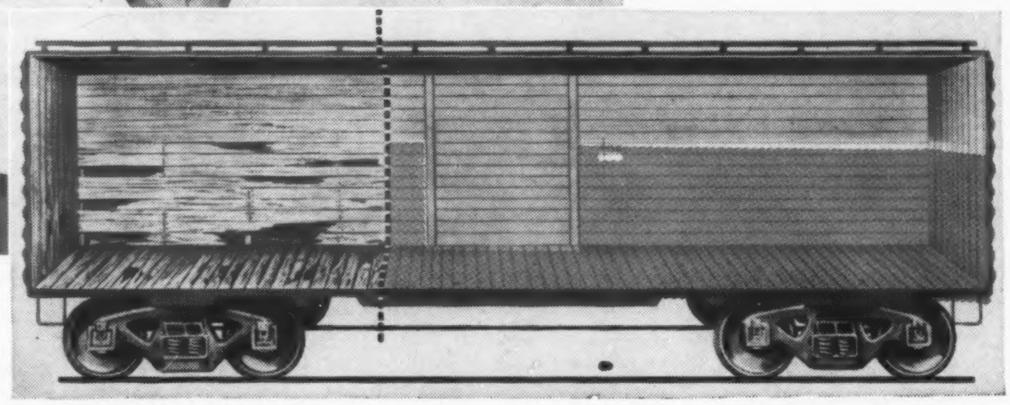
Durez Plastics Div., Hooker Electrochemical Co.



"Beat-up boxcars made like new with Espey Carliner!"

Reichhold polyester resin used in Espey Carliner is applied over glass cloth on floor of freight car. The resin coating goes on easily, dries fast to a hard, durable surface.

Low-cost lining provided by Espey Carliner covers cracks, gouges, oil spots. It seals seams, joints and corners against moisture and vermin. Old car is transformed into top-revenue carrier.



Tough RCI resin coating upgrades old cars in just a few hours!

• The heavy industrial equipment transported by railroads splinters and spoils wooden walls and floors of freight cars. This wear-and-tear progressively downgrades the cars to class C or D — cars unsuitable for commodities like edible grains.

Now, however, the Espey Carliner, developed by Spring Packing Corp. of Chicago with technical help on resin coatings from Reichhold, returns these cars to "class A" status. *In fact, Carliner treatment actually results in car walls and floors that are "better than new!"*

Two coats of special RCI polyester resin, brushed onto glass cloth, do the job quickly and economically. The resulting interior surfaces are *harder, more durable, more easily cleaned, provide better insulation, and are more resistant to moisture and chemicals than the original wooden walls and floors.* The lining is unaffected by freezing, heat, corrosion or shock.

"Reichhold was a great help to us with technical service" says John T. Landreth, president of Spring Packing. "They worked closely with our people, tailored just the right polyester resin formulation for our need. And they make fast deliveries, too!"

Whether *you're* interested in plastic coatings, molded or laminated plastics, RCI Technical Service can find a resin formulation that gives *you* important advantages, too! Write RCI about polyesters for your products. And ask for *booklet A.*

Creative Chemistry . . . Your Partner in Progress

RCI

REICHHOLD

Synthetic Resins • Chemical Colors • Industrial Adhesives • Plasticizers
Phenol • Formaldehyde • Glycerine • Phthalic Anhydride
Maleic Anhydride • Sodium Sulfite • Pentaerythritol • Pentachlorophenol

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N. Y.

For more information, turn to Reader Service card, circle No. 541

Magnesium casting alloy

To the Editor:

I have just read, in your July issue, Manual No. 139 on "Magnesium and Its Alloys." In Table 3 figures are given for typical tensile properties at room and elevated temperatures for casting alloy ZK61A-T6. The figures for this particular alloy are below minimum results obtainable on sound, separately cast test bars. As listed in Table 1, ASTM B 80 specifies the minimum tensile properties as 40 kpsi ultimate tensile strength, 25 kpsi yield strength and 5% elongation. Canadian specifications are 42 kpsi ultimate tensile strength and 26 kpsi yield strength. The values listed in Table 3 could not have been obtained from a fully heat treated test bar unless the composition (zirconium content) was wrong, or a big hole or other gross defect occurred (even severe microporosity couldn't account for such low yield strength).

You will find enclosed a copy of our paper presented in 1953 to the American Foundrymen's Society on the "Characteristics of High Strength Magnesium Casting Alloy ZK61," and I should like to call your attention to the typical room temperature properties listed in Table II and typical tensile properties at elevated temperatures given in Table V (these, as listed in your table, are much too high). Having tested many thousands of test bars in this alloy, I can assure you that a "saleable quality" test bar is always around 45 kpsi in ultimate tensile strength, above 30 kpsi in yield strength, and 8-10% in elongation.

In connection with the wide distribution of your magazine, it is regrettable that such erratic figures were included in your Manual.

J. W. MEIER
Principal Metallurgist
Dept. of Mines and Technical Surveys
Ontario, Canada

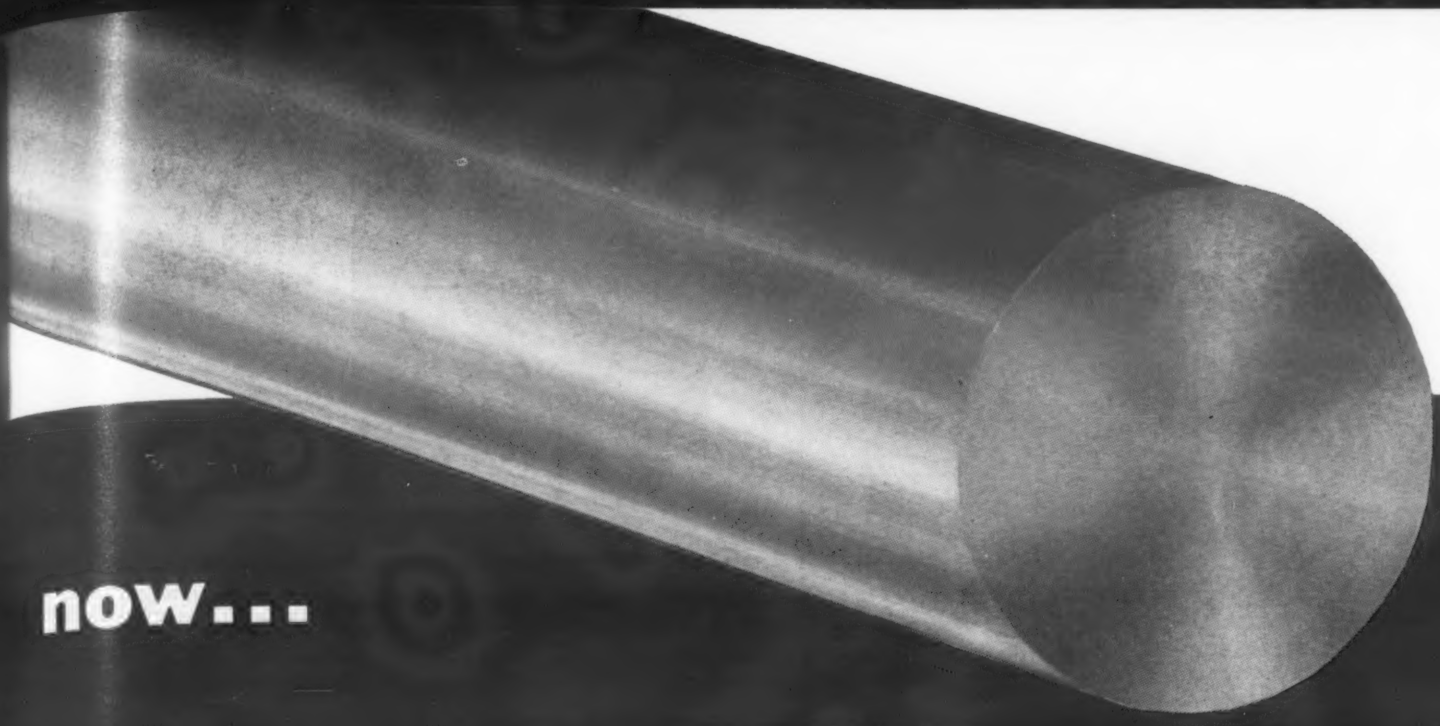
We appreciate having these apparent discrepancies brought to our attention and are hoping to receive a statement from the authors of the manual.

Search for a joint material

To the Editor:

I would appreciate suggestions in connection with this problem: to provide a vacuum-tight, rigid or elastically deformable joint where the radiused lips of two cylindrical metal tubes meet in circular, line-like contact. The ends of the lips are coated with porcelain enamel. This coating, and also the joint material, will be exposed to the intense visible and invisible radiation from a gaseous electrical discharge in vacuo.

What is needed is an inorganic joint material,



chemically inert both to the gases (principally hydrogen) and to the porcelain enamel coating, with a bonding strength equal to 1000 psi in tension. This joint material should be either dielectric or semiconductive in nature; it should also be adhesive-like and applicable at room temperature, but able to be cured, if necessary, to 800 F maximum.

S. E. OPENSHAW
Design Draftsman
University of California
Livermore, Calif.

A report that may help was recently published by the Office of Technical Services; it is Research on Elevated Temperature Resistant Ceramic Structural Adhesives, *by H. G. Lefort, R. M. Spriggs and D. G. Bennett, Dept. of Ceramic Engineering, University of Illinois. It may be ordered from OTS, U. S. Dept. of Commerce, Washington 25, D. C., ($2.00), order number PB 121941. The Wright Air Development Center, Materials Laboratory, Wright-Patterson Air Force Base, Ohio may also be able to help.*

Help requested

To the Editor:

I would appreciate answers to the following: 1) the name of one or more companies making glue as used in making molds for vessels in cement or concrete; and 2) the name of a firm in California or the West which could impregnate wooden boxes for use with aqua ammonia at a lower cost than using acrylic.

J. B. MERIAM
Chairman of the Board
Meriam Instrument Co.
Cleveland, Ohio

A list of adhesive manufacturers has been sent. Information on wood impregnation can be obtained from Forest Products Laboratory, Dept. of Agriculture, Madison 5, Wis.

Beryllium oxide ceramics

To the Editor:

Ceramics containing beryllium oxide may offer a solution to a heat transfer problem encountered in the design of our three billion volt proton synchrotron. Please send us the names and addresses of manufacturers providing such porcelains.

M. SZEKELY
Staff Engineer
Princeton University
Princeton, N. J.

Two companies who produce these materials are: National Beryllia Corp., 4501 Dell Ave., North Bergen, N. J., and Clifton Products Co., Painesville, Ohio.

ONE POINT OF VIEW

One way to beat high prices of materials

Like everything else, prices of materials keep going up. Despite some spot decreases in nonferrous metals and nonmetallics, prices have continued to rise steadily since the war. And barring a depression, chances are they will continue to increase. Just within the past few months steel has jumped $6 per ton, aluminum has advanced 1¢ per lb, high density polyethylene is up 3¢ per lb and, effective Nov 1, the price of phenolic molding resins increased 1¢ per lb.

What to do

What can you, the product manufacturer who must live with these rising prices, do about it? Many companies are automatically raising the prices of their products to take care of the increases. But many others can't take this easy way out and survive. They must find other ways.

One of the best approaches to the problem, which may appear obvious but is often overlooked, is to re-evaluate the materials used in your products. A thorough-going appraisal will often reveal many possibilities for lowering materials costs. You may find that a less costly material, material form or finish can be used without change in design. On the other hand, a redesign may be necessary to use less material or to take advantage of lower priced materials. Or you may discover that a change in the material or the form of the material might lead to a significant reduction in production costs.

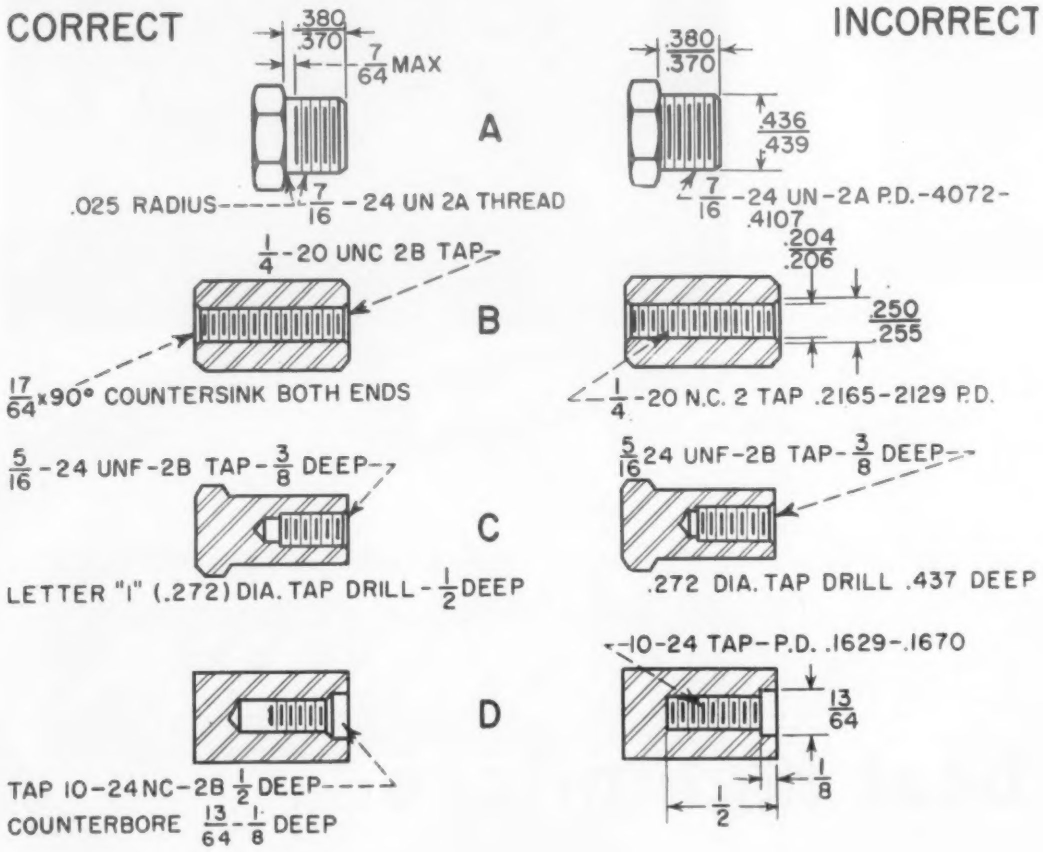
It works

If any is needed, there is ample proof that re-evaluation of materials used in product designs does pay off. Our Awards Competition for "Best Use of Materials in Product Design" brought forth many outstanding examples of how materials costs can be drastically cut through re-evaluation and judicious design. The top award winning entry made use of a plastics foam sandwich construction in place of conventional steel for refrigerator walls. The result was a saving in tooling costs of over a million dollars. Savings realized by four of the other award winning entries ran anywhere from 65 to 80%.

Another example

The value analysis program at General Electric Co. is another illustration of how material costs can be reduced by product re-evaluation. For example, changes in materials for a simple electrical contact assembly resulted in total savings of $48,000. The changes included such simple things as the elimination of plating by switching to preplated stock, specifying a cold headed part in place of a screw machine part, and replacing expensive music wire with a less expensive spring wire.

The examples just described are only a small indication of what can be done. Re-evaluation of the materials used in in your parts or products will probably uncover similar opportunities for cost reductions to offset rising materials prices.



1. *How to specify threads*

The right hand drawings are incorrect because:

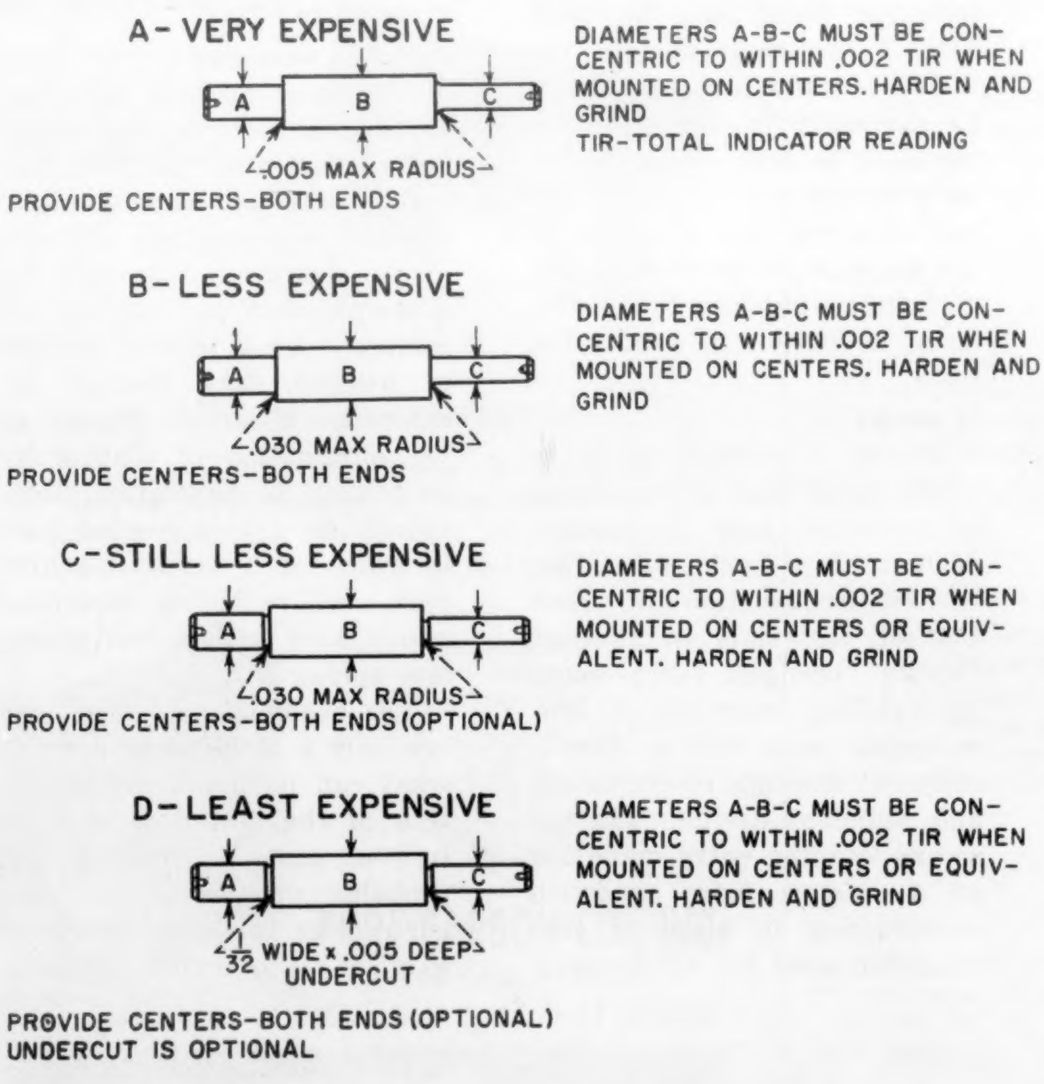
A—part is shown with threads to shoulder, o.d. dimensioned to close tolerance, and p. d. (pitch diameter) specially dimensioned, thus requiring special gages.

B—unnecessary dimensions are given for minor tap diameter, and p. d. is a special size requiring special gages.

C—insufficient room is left for tap (in a blind hole).

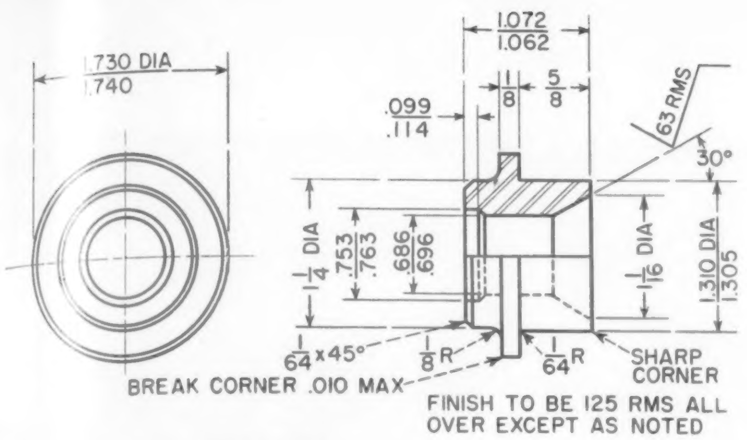
D—drawing calls for a tapped flat-bottom hole. In most cases angle of drill point is not objectionable and should be shown on drawing.

These rules will help you in Designing for



2. *How to specify close tolerance diameters*

Schematic diagram of a shaft on which all three diameters are to be held to close tolerances. The part requires hardening and grinding. The first method, **A,** is most expensive because grinding centers must be used and the small radius specified makes frequent wheel dressing necessary. **B** is an improvement because the larger radius specified reduces the number of wheel dressings required. **C** simplifies the part because the note "when mounted on centers —or equivalent" permits centerless grinding and checking in a Vee block and indicator. **D** is the most economical design since optional undercuts produce the same effect as a sharp corner, and centerless grinding can be used. For most practical purposes **D** costs about half as much as **A.**



3. *How to indicate . . .*

Radii—A radius requires careful blending of two surfaces and usually increases costs.

Corners—If a sharp corner is required, it should be specified. Limits on breaking corners must be shown.

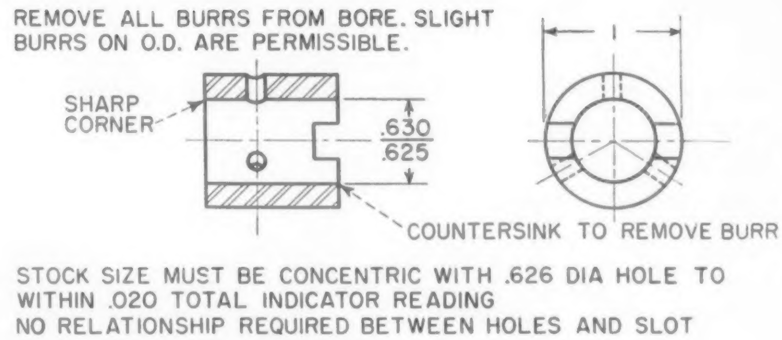
Chamfers—Use a chamfer instead of a radius for intersecting surfaces that must be free from burrs.

Bore—Use commercial tolerance unless closer tolerances are required. Drawing has depth and diameter tolerances of 0.010 in.

Finish—Seating surface finish clearly indicated. Note gives over-all finish.

Diameters—Specified in fractions on surfaces not required to fit another part.

Note: End view is dimensioned to permit advantageous use of standard stock sizes.

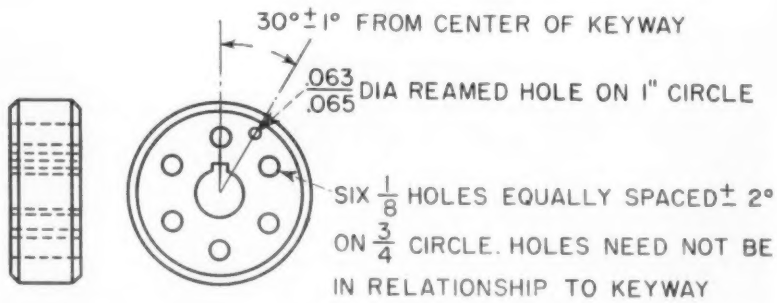


4. *How to indicate . . .*

Concentricity—The part is not required to fit anything on the outside diameter, making it possible to use a stock size with concentricity indicated.

Burring—Removal of burrs from bore only reduces cost.

Location—Elimination of hole and slot relationship reduces cost.



5. *Keyway-hole location*

Some holes require no definite relation to keyways. Unless the designer indicates this fact, the producer will plan to use special fixtures, thus increasing the price unnecessarily.

6. *Commercial tolerances*

Diameters
Fractional ± 0.005 in.
Decimal ± 0.003 in.

Lengths
Fractional ± 1/64 in.
Decimal ± 0.010 in.

Angles and holes
Angles 2½ deg
Drilled holes −0.001 to +0.010 in.

Fillets
0.020-in. max radius

Corners
Dia < ½ in.: 0.020-in. radius or 0.005 in. x 45-deg chamfer
Dia ½ in. or >: 1/64 in. x 45-deg chamfer

Screw Machine Parts

by **John L. Everhart,** *Technical Editor, Materials in Design Engineering*

■ Among the many screw machine parts are such things as bushings, bearings, shafts, instrument parts, aircraft fittings, watch and clock parts, pins, bolts, studs and nuts. Screw machine parts can be produced at rates up to 4000 parts per hour, and tolerances of ±0.001 in. are common. In addition, screw machine parts can be made of practically any material that is machinable and that can be obtained in rod form. In comparison, die casting is restricted to a limited number of alloys of relatively low melting point, and cold heading requires materials that are ductile at room temperature.

However, screw machine parts do have certain limitations:

1. Since the material must be in the form of bar or rod, the cross section of the part is generally limited to a circle, hexagon, square or other readily available extruded cross section, although a special extruded cross section can sometimes be ordered. The stock used must be as large as the greatest cross section of the part; depending on the shape, this may or may not result in large scrap losses. In general, irregular and nonsymmetrical parts are not good screw machine parts, although some parts of this type are produced.

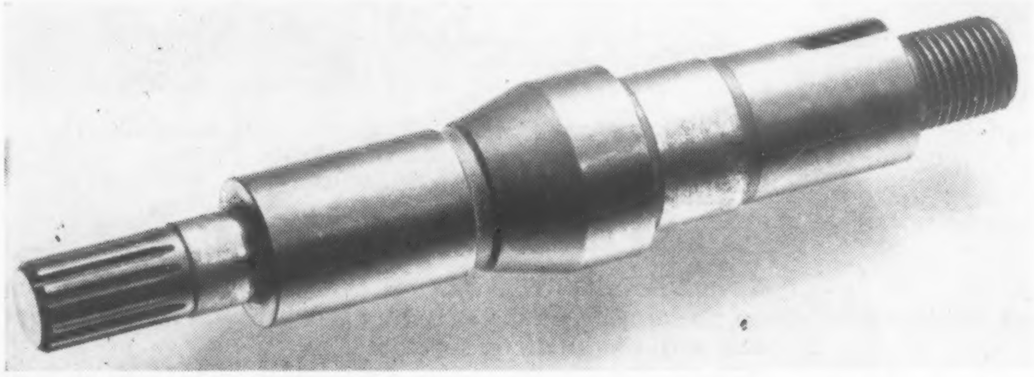
2. Parts can become quite expensive unless certain restrictions are observed in selection of material and in design of parts. These restrictions and other design suggestions are given in this article.

Materials

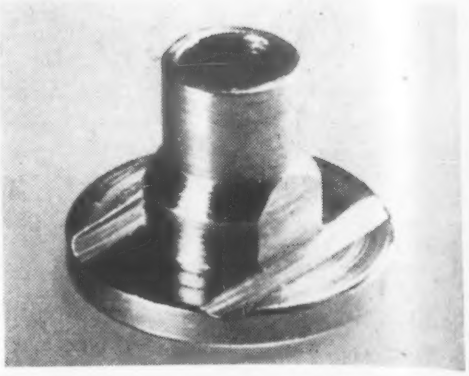
Selection of the material is very important. Cost of producing a part is influenced greatly by ease of machining; poor machinability reduces tool life and causes frequent shutdown to replace tools. If service requirements permit, readily machinable materials, such as resulfurized steels or leaded brasses, should be given preference.

Some of the many metals used

Some typical screw machine parts

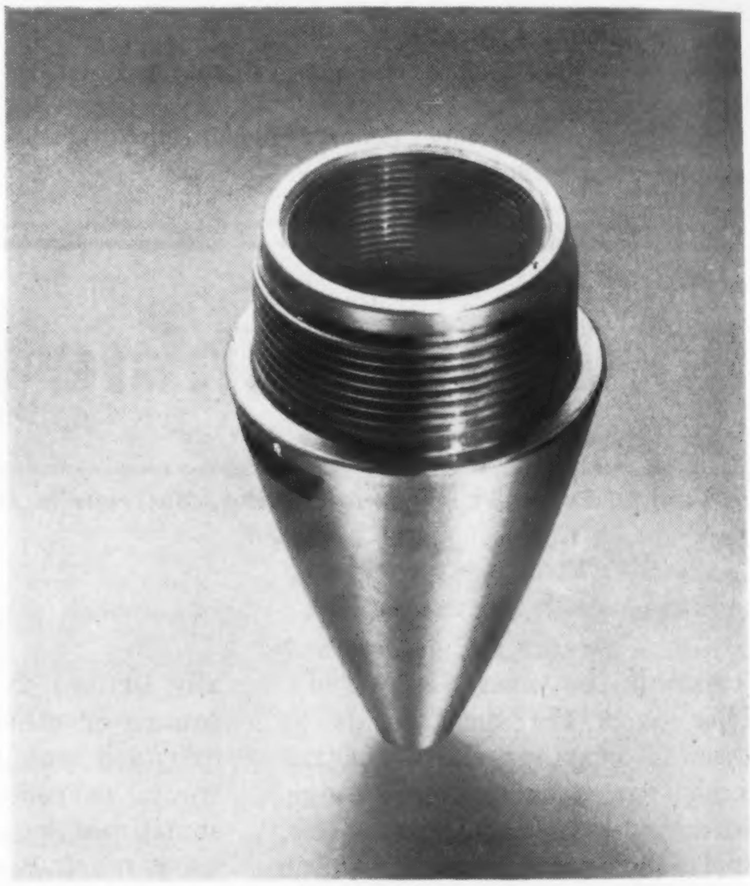


Power steering shaft *of Stressproof steel is threaded on a screw machine. Secondary operations include profile grinding on all diameters; holding a 0.0002-in. tolerance on bearing sections behind splines and between undercuts.*



Terminal rivet *was converted from cold headed part of SAE 1010 steel to screw machine part of Ledloy steel. Cold heading failed to retain required concentricity and parallel flat sections.*

Swivel lamp assembly *of two brass pieces. Both parts completed on screw machine, including internal and external threads. Parts joined in a second operation by spinning the middle section over the ball.*



Rocket nose *made from 1¾-in. steel bar stock. Milling the slots was the only secondary operation.*

in screw machine parts are: carbon and low alloy steels; stainless and heat resisting steels; cast and malleable irons; copper alloys, particularly brass, bronze and nickel silver; aluminum and magnesium alloys; nickel and cobalt superalloys; and gold and silver. Among the nonmetallic materials used are vulcanized fibre, hard rubber, nylon, Teflon, methyl methacrylate, polyethylene, polystyrene and phenolics.

Lot size should be considered in selecting the material, as it influences not only the cost of the part but the material that can be used. Generally, for a lot size of less than 500 lb, materials are limited to those stocked in warehouses. For a lot size of a ton or more, orders can be placed with a mill and a wider range of materials is available. However, delivery may be considerably slower than from warehouse stocks, and delays of three or more months are not uncommon.

Price per pound is a function of lot size. The per-pound price of a material ordered in 75-lb lots can be twice that of the same material in 500-lb lots.

Polymer Corp. of Pennsylvania

Bushings, gaskets, *seals and insulators produced on the automatic screw machine from Teflon.*

Design

Screw machine parts should be designed to be made from standard compositions, standard stock sizes and standard shapes. Specifying nonstandard bar not only increases costs but may result in delays in obtaining the parts.

Tolerances—Commercial tolerances are given on page 121. Closer dimensions can be held but should be specified only when necessary, since they increase the cost of producing and inspecting the part.

Holes—Standard drill sizes should be specified if possible. When holes require reaming, sizes that can be finished with standard reamers should be specified.

Threads—A major item in the design of a screw machine product is the selection of a proper standard thread, the aim being to provide interchangeability. In new designs, use the Unified Screw Thread System, adopted by the United States, Canada and Great Britain. For existing designs, however, continue to use the American National System. Indicate threads by size, pitch, series and class, only; using a special pitch and specifying major and minor diameters is often unnecessary and always expensive.

On screw machine products having tapped holes, you can save considerable money by adopting a thread depth that is no greater than the application demands. Tests have shown that accurately made threads that are 65% of full thread depth, and equal or greater than the screw diameter, have ample strength to meet most commercial requirements. Excessive percentage of thread in tapped holes can cause increased tap breakage, machine down-time and inspection cost.

Concentricity—When concentricity is required, specify it in terms of total indicator reading (TIR) rather than as a dimension. It is good engineering practice to indicate the diameters that must run true by an arrow leading to a note reading "diameters marked A must be concentric to within —— TIR measured at points ——." Specifying concentricity when it is not required increases cost of the part unnecessarily.

Burrs—Do not specify removal of burrs unless this operation is essential. Since there is some doubt about the definition of a burr, the screw machine industry has established certain criteria:

1. Sharp corners are not considered burrs unless they have ragged edges and interfere with operation of the part.
2. Slight tears or roughness on the first two threads of a tapped hole or the male thread are not burrs unless they interfere with assembly.
3. A projection is not a burr if it must be found with a magnifying glass.

Burrs can be eliminated in most cases without additional cost by specifying chamfered or rounded corners on the parts.

Finish—In general, cost of finishing will depend on the degree of finish required; the finer the finish, the higher the cost. A finish for appearance only need not be as fine as a finish required on mating or bearing surfaces. In any case, finish should be specified in terms of microinch rms units. Microinch finish depends on material and operation and without secondary operations can range from the usual 125 rms to as low as 16 rms. The latter finish requires special care and is a very high cost operation on a production basis.

Dimensions—If a part requires heat treatment or plating, dimensions supplied to the part producer will depend on where these operations are to be done. If the supplier is to finish the part, give dimensions to apply after heat treatment or plating; if the buyer is to finish the part, give dimensions to apply before heat treating or plating.

Acknowledgment

This article was prepared with the assistance of the members of the National Screw Machine Products Assn. Drawings and photographs were supplied by the association, except where otherwise credited.

Bulk, *the basic form of the fiber, is used for many insulating applications.*

Batt *is used for air conveying of hot materials. Batt here is sewn with stainless steel wire.*

Ceramic Fiber –
Seven Forms and How to Use Them

Since the development of strong, lightweight aluminum silicate fiber several years ago, many prefabricated forms have been developed. Here is information on how these various design forms are used in current high temperature applications.

by C. B. Walworth, *Senior Engineer, Research and Development Div., Carborundum Co.*

■ Originally developed for jet engines, aluminum silicate fiber has become important for many other applications where design requirements call for a high temperature resistant (1000 to 2300 F), lightweight, strong, fibrous material with low thermal conductivity. It is used for a variety of high temperature applications, including thermal, acoustical and electrical insulation; filters; and packings and gaskets.

Though originally available in fiber form only (MATERIALS & METHODS, Sept '52, p 94), in recent years the material has become available in a variety of prefabricated forms, each of which provides maximum design effectiveness for specific applications.

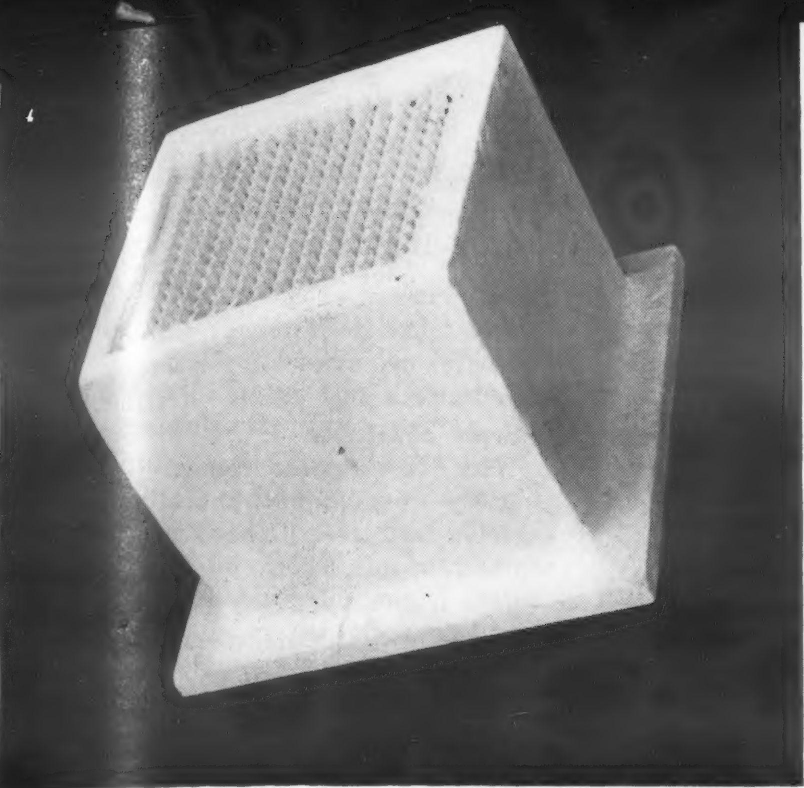
Bulk

One of the major uses of aluminum silicate fiber in bulk form is high temperature insulation. Applications include furnace hot-topping, heating element cushions and jet engine blankets. The bulk fiber is also used as an expansion joint packing in kilns and furnaces to reduce heat losses and help maintain uniform furnace temperatures. In an early application, short staple fiber was packed as a lining for stainless steel cans used as combustion tubes in gas and oil fired turbines.

Brazing furnaces—Short staple fiber is used in place of asbestos in continuous brazing furnaces to cushion aluminum and copper parts. Use of the material results in lower maintenance costs and longer life; the aluminum silicate fiber withstands 150 trips through the brazing cycle as compared with two or three cycles for asbestos.

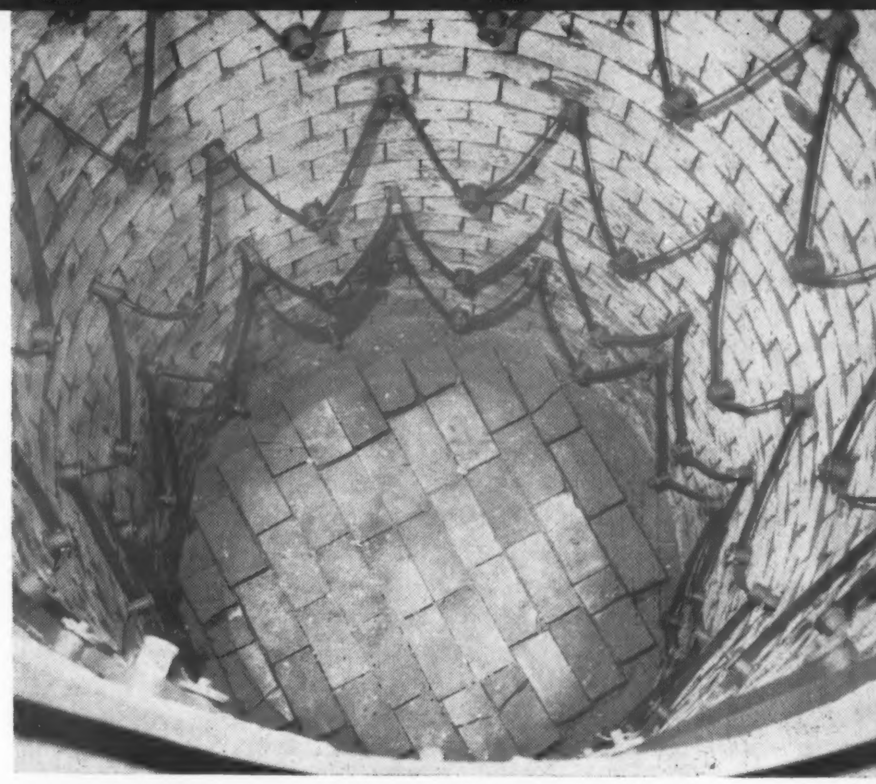
Furnace rolls—Many of the insulation applications for which bulk fiber is used also require that the insulation be vibration resistant, i.e., fibers must not be shaken loose during service. Long staple fibers provide better vibration resistance than short staple. This improved vibration resistance is an important requirement when bulk fibers are used for insulating rolls that convey steel and alloy sheet metal through annealing furnaces.

These rolls are normally fabricated by assembling a series of



Buffalo Forge Co., Flanders Mill

Paper, *pleated to provide more surface, is used in this filter unit for high temperature gases.*



Block *makes insulating wall for furnace used to produce graphite tubes for Graphite Specialties Corp.*

refractory cylinders on a long, water cooled, steel tie rod; pressure is applied at each end of the roll to hold the refractory cylinders under compression. Long staple aluminum silicate fiber is used as a bulk packing inside the rolls to protect the rod from heat built up in the refractory roll surfaces.

Gas filters—Long staple aluminum silicate fiber is used to filter gases in the 1400 F range. Coarse, medium coarse or fine grades, or composites of these grades, can be specified to obtain the desired filter characteristics. Filter efficiency and resistance for long staple fiber in bulk form are shown in Table 1.

Batts

Batts are formed by bulking the fiber into a blanket like shape, which is held together mechanically with wire or a similar fastening device.

Air conveyors—When conveying extremely hot materials, the fiber in batt form is placed in the bottom of an air chamber. Hot solids from roasting or calcining operations are fed into the upper part of the chamber, and air passing through the fibrous batt keeps the solids suspended for transfer to other processing areas. The air may also serve to cool the solids. The fiber batt is suitable for such uses because of its high temperature resistance, its air permeability, and the fact that it does not deteriorate when hot suspended solids are deposited on the batt during shutdown.

Engine silencers — Fiber batts are currently being evaluated as acoustical insulation for jet engine test cells. In addition to good acoustical absorption characteristics, such batts have the necessary resistance to high temperatures and vibration. Though specific test results are not yet available, manufacturers' reports are encouraging.

Paper

Applications for paper made of aluminum silicate fiber (M&M, Dec '55, p 98) include high temperature linings, filters, gaskets, fabrication aids and electrical applications. Electrical uses should grow because of the inherent combination of good electrical insulating properties and high heat resistance. The paper is available in thicknesses of 20, 40 and 80 mils. Papers less than 10 mils thick suitable for applications such as wire and coil wrapping are difficult but not impossible to produce.

TABLE 1—FILTER EFFICIENCY AND RESISTANCE[a]
(Long staple fiber)

Type of Fiber ↓	Filter Depth, in.	Packing Density, lb/cu ft	Gas Velocity, fpm	Gas Temp, F	Filter Res, in. H_2O	Dust Loading, gm/1000 cu ft	Weight Efficiency, %
Coarse	4	2	400	70	1.2	9.2	85
		3	400	1400	1.7	20.3	83
		2	700	1400	1.4	16.3	82
Medium Coarse	1.5	3	350	70	1.7	30.1	99
		3	400	1000	2.2	33.9	94
		3	700	1400	—	16.4	84
Fine	1	2	350	70	2.4	36.8	98
		2	400	1400	2.3	34.3	91
		2	700	1500	3.7	6.6	85
Composite[b]	—	3	400	70	5.1	13.1	99+
		3	400	1400	5.3	10.8	99+

[a]Aerosol used was technical grade cupric oxide; median particle size was 8.5 microns.
[b]Composite filter contained 5 in. of coarse fiber, 1 in. of medium coarse fiber, and ⅛ in. of fine fiber.

Aluminum Silicate Fiber: Its Basic Properties

Traditional inorganic fibers such as glass, mineral wool and asbestos provide excellent service at temperatures up to 1000 F. Exposure above this temperature seriously degrades these materials. Aluminum silicate fibers are primarily intended to serve in similar types of applications at temperatures ranging from 1000 to 2300 F, i.e., in the range between previously available inorganic fibers and insulating refractories. The accompanying table compares some properties of four types of aluminum silicate fibers with those of glass fibers, mineral wools and asbestos.

Properties

Aluminum silicate fiber has a melting point of over 3000 F, and a maximum use temperature of 2300 F. When exposed to temperatures in excess of 2000 F for long periods of time, the material undergoes devitrification, i.e., the amorphous or random crystalline orientation changes to a definitely arranged pattern. This phase change makes the fiber more brittle, lower in tensile strength, and more easily abraded. There is also some indication of shrinkage. There is no evidence of melting at temperatures under 3000 F.

Because many of the uses for the fiber are as high temperature insulation, thermal conductivity measurements with a guarded hot plate apparatus have been made on a number of commercially available forms. The accompanying curves show thermal conductivity versus mean temperature for four fabricated forms.

Types produced

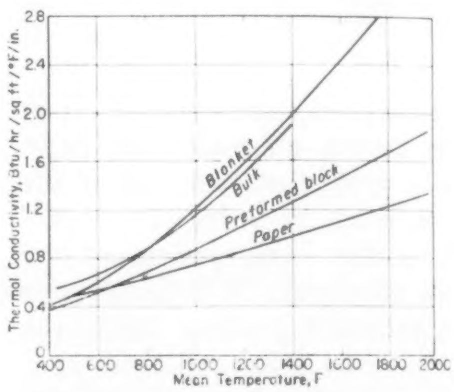
Aluminum silicate fibers are produced either as short staple fibers, or as long staple, textile grade fibers. The long staple type is produced fine, medium coarse or coarse to suit individual uses.

Short staple fibers are produced by passing the molten aluminum oxide-silica (1:1 ratio) stream, which contains small quantities of sodium and boron to help control the melt, into a high velocity air or steam jet. The jet disintegrates the stream into very fine particles or droplets, and attenuates these droplets into fine fibers as they cool rapidly. The fibers are carried away by suction and collected for processing.

Long staple fibers of controlled diameters are produced by a recently developed process in which small quantities of zirconia are added to control the melt. Coarser varieties are available for specific applications such as air filtration.

Forms available

The fiber is prefabricated in a variety of standard shapes for specific end uses. The standard forms: staple fiber; bulk fiber; batts; paper; blankets and other textiles, such as rope, roving, yarn and cloth; castable; and board and molded shapes. "Fiberfrax" is the registered trademark for Carborundum Co.'s aluminum silicate fiber and prefabricated forms in which it is available.



***Thermal conductivity** versus mean temperature for four forms of fiber.*

A COMPARISON OF INORGANIC FIBERS

Type of Fiber	Chemical Composition	Color	Fiber Diameter, micron	Fiber Length, in.	Tensile Strength, psi	Melting Point, F	Max Use Temperature F	Specific Gravity
Ceramic								
Short Staple	Aluminum silicate with soda and borax	White	Max 10, min 0.5, mean 2	¼–½	—	3300	2300	2.73
Long Staple (fine)	Aluminum silicate with zirconia	White	Max 40, min 2, mean 4	½–10	180,000	3300	2300	2.73
Long Staple (medium coarse).	Aluminum silicate with zirconia	White	Max 40, min 3, mean 10	½–10	115,800	3300	2300	2.73
Long Staple (coarse)	Aluminum silicate with zirconia	White	Max 80, min 4, mean 20	½–10	50,000 (est)	2600	1600	2.73
Others								
Glass (textile grade)[a] ...	Silicates of soda and lime	White	50–90	Filaments	204–220,000	1500	600–1000	2.54
Mineral Wools[b]	Silicates of iron, calcium, magnesium	Brown to off-white	2–35	¼–10	60,000	2000	600–800	2.5 (approx)
Asbestos[b]	Hydrous silicates of calcium, magnesia, iron, soda	White to green or brown	0.17–0.03	Short to long	80–100,000	2400	1000	2.5–3.3

[a]Source: *Synthetic Fiber Table*, McGraw-Hill Publishing Co., 1953.
[b]Source: Badollet, M. S., "Asbestos, A Mineral of Unparalleled Properties," *Canadian Mining and Metallurgical Bulletin*, Apr., '51.

High temperature linings—The thin gage and low thermal conductivity of such papers make them useful high temperature lining materials. Many nonferrous metals, such as aluminum, magnesium and some brasses and bronzes do not readily wet or attack the aluminum silicate fiber. Thus paper made from the fiber can be used to line metal ducts, ladles, crucibles, spouts, launder systems, ingot molds, and other metal components used to handle these molten metals.

The paper is also used as a lining for combustion chambers in oil fired domestic heating units. The paper protects the steel wall of the chamber from direct flame impingement. Test units have met requirements of Underwriters' Laboratories.

Gaskets—The paper is used for gaskets on pressure vessels, flanges, orifice blocks and other equipment that encounter high temperatures and make use of moderately low pressures. Because of the relatively high porosity of the paper, it can be impregnated with silicones, fluorocarbons and similar heat resistant impregnants to adapt the paper to higher pressure gasket applications.

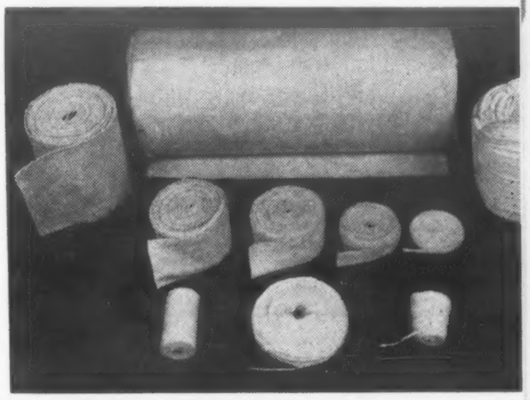
Processing aids—The paper can also be used as process and fabrication aids. It is used successfully as a brazing cushion in making brazed stainless steel honeycomb sandwich structures. Dimensional stability and inertness are primary requirements.

Blocks

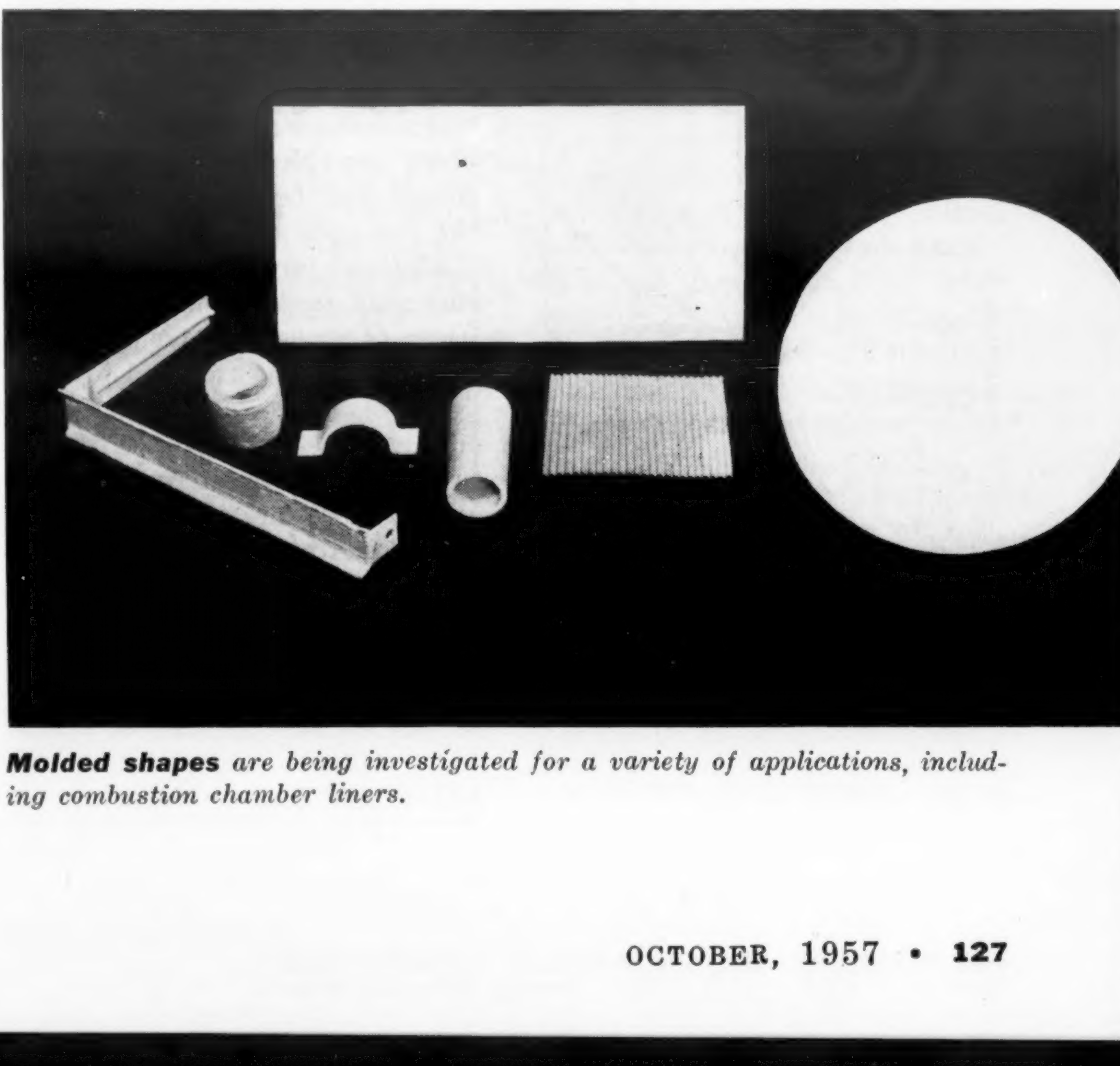
Preformed blocks are made of short staple fibers and suitable fillers and binders which do not reduce the 2300 F maximum service temperature of the material. The curves on p 128 show the insulating value of various thicknesses of bonded blocks at various hot face temperatures.

Aluminum silicate blocks are used to reduce hot wall temperatures in industrial furnaces, kilns and combustion chambers. The block provides lower heat losses and lighter walls as compared with many conventional refractory fire bricks.

Textiles *woven from the fiber include blankets used for high temperature pipe insulation, tapes, ropes and webbing.*



Castable *is used to insulate drying lid. Note contour around burner blocks.*



Molded shapes *are being investigated for a variety of applications, including combustion chamber liners.*

TABLE 2—TYPICAL BREAKING STRENGTHS OF ALUMINUM SILICATE TEXTILES (Lb)

Type of Textile	Base Weight	Normal	After 24 hr at 1000 F	At 1500 F	At 2000 F
Rope (½ in.)	30 ft/lb	80	—	—	—
Rope (¼ in. with nickel-chromium wire insert)	46 ft/lb	300	—	—	—
Cloth (twill weave)	32 oz/sq yd	44	7	6	—
Cloth (plain weave with stainless steel wire insert)	26 oz/sq yd	53	27	25	—
Cloth (double weave with wire insert)	55 oz/sq yd	168	—	97	—
Cloth (twill weave with nickel-chromium wire insert)	40 oz/sq yd	117	96	72	52

TABLE 3—TYPICAL PROPERTIES OF FIBER BOARD

Color	White
Density, lb/cu ft	25-60
Breaking Strength (cross, ⅛ in. thick), psi	1000
Shrinkage (after 24 hr at 1500 F), %	0.4
Thermal Shock Resistance	Excellent

TABLE 4—ELECTRICAL CHARACTERISTICS OF FIBER BOARD

Frequency, cps	Temp, F	Dielec Const	Loss Tangent
10^2	Room	4.81	0.654
10^5	Room	1.75	0.040
10^8	Room	1.61	0.017
1.4×10^{10}	Room	1.60	0.036
8.6×10^9	266	1.57	0.0078
	590	1.569	0.0055
	930	1.560	0.0063

Devitrification may occur in combustion applications because of the high temperatures, but the temperature gradient through the block is such that devitrification is generally confined to the hot face of the block. In a number of cases the block appears to be stronger after exposure to devitrifying conditions than before. Apparently exposure to high heat conditions does not seriously degrade the insulating properties of the blocks, and such blocks can be re-used even though the hot faces may be more easily abraded and show some surface shrinkage.

Oil fired furnaces—The blocks are used to line the combustion chamber of an oil fired furnace. Use of the blocks reduces slag build-up on the chamber wall, and little if any erosion from direct flame impingement occurs. The lightweight block also eliminates the need for a forced air "after purge" of the furnace. Purging is now done entirely by bleed-down of the primary air pressure chamber and by natural draft through the secondary air control damper and blower.

Tunnel kilns—The good resistance of aluminum silicate blocks to thermal shock is of particular advantage when the blocks are used as roof tiles in tunnel kilns. Tunnel kiln operations occasionally involve jam-ups because of movement of skidrails or ware-supporting setter plates. Usually substantial production time is lost waiting for the kiln to cool slowly in order to avoid fracture or spalling of the insulating brick. Kilns insulated with aluminum silicate block can be cooled more rapidly because of the material's superior thermal shock resistance. Also, the block can be re-used after the tunnel has been dismantled and the jam-up straightened out.

Electric furnaces—Blocks are currently used to line electric furnaces (4 to 6 ft in dia and 10 to 15 ft long) that are used to form graphite tubes. The blocks are cut into 6-in. wide strips and pressed or bevel-cut to fit the inside contour of the steel vessel. The blocks provide effective insulation while maintaining a furnace firing temperature of 1650 F (±70 F) for several days. The blocks have provided satisfactory service for several years of operation without deteriorating in either oxidizing or reducing atmospheres or after contact with pitch vapors and sulfur gases.

***Insulating value** of various thicknesses of block as shown by cold face temperatures at various hot face temperatures.*

Textiles

Several types of high temperature resistant textile products have been developed in the last three years. These products, made from long staple fibers, include blankets, roving, yarn, rope, tape and broad woven textile goods. Table 2 lists typical breaking strengths of several of these materials. Yarns reinforced with glass filaments, alloy wire and other reinforcements have been produced experimentally.

Blankets — Aluminum silicate fiber blankets are used as high temperature insulation in furnace tops, sidewalls and ducts; turbine exhaust lines; and superheated steam piping. For piping applications the blanket is particularly well suited for insulating fabricated sections such as flange and valve covers and elbows. These insulations are usually assembled by encasing the blanket in a flexible alloy wire screen or heat resistant cloth and stitching the assembly together. Removable coverings can be made up in this manner.

The degree of insulation obtainable with these blankets is indicated by an installation in an incinerator used to burn exhaust fumes generated in a paint spray

operation. The blanket reduces a combustion chamber temperature of 1600-1700 F to a safe level of 150 F on the outside shell.

Aluminum silicate blankets are also used as a packing between firebrick linings of a petroleum refining furnace. The firebrick expands and contracts with fluctuating temperatures in the furnace, and the blanket acts as an expansion joint filler as well as a seal against gas leakage.

Combinations of aluminum silicate blankets and glass fibers or asbestos materials offer interesting possibilities. The blanket is used to reduce the temperatures to a safe range for the glass or asbestos. A flange cover recently assembled by Philadelphia Asbestos Corp. for superheated steam piping reduces a hot face temperature of 1100 F to about 100 F on the cold face through 2½ in. of aluminum silicate blanket and 1½ in. of glass fiber blanket. The resulting assembly is about one-half the weight of conventional insulation.

Other textiles—A number of applications are now being investigated for the other textile products. Among these are gaskets and seals in heat treating furnaces, rope packings for molds (between the hot top and the ingot mold) in steel manufacture, bag filters for collecting hot carbon and chemicals, and electrical wire winding and wrapping.

Castables

A castable aluminum silicate fiber composition has been developed by using some of the new high temperature binder materials. Aluminum silicate offers extremely good thermal shock resistance, low thermal conductivity and much lower density than previously available castable refractories. In addition to drying lids and pressure vessel linings (discussed below), castable aluminum silicate fiber has been used experimentally on boiler access doors, and as incinerator linings, duct insulation and induction furnace shielding.

Drying lids—Castable aluminum silicate is used in a lid for drying and setting ceramic linings in casting pots. The lid is exposed to a temperature cycle of room temperature to more than 2000 F. Burner blocks are mounted on the lid, and an air-gas mixture is burned to provide a heat source. In operation the castable surface is suspended over the casting pot and thus is in direct contact with the flame sweep during firing. Lids made of other types of castable refractories weigh between 1500 and 2000 lb. For an equivalent thickness, the aluminum silicate lid weighs only 350 lb.

Pressure vessels—The castable is used as a lining for pressure vessels. The lining is installed on the inner wall of the vessel, and conforms to the contours of the top and bottom, as well as the inlet and outlet ports. In one application, the vessel is designed to withstand 300 psi gas pressure at 1500 F. The lining, applied 2 in. thick, permits the original 2-in. thick stainless steel wall to be replaced with a ½-in. carbon steel wall.

Molded shapes

Rigid, structural molded shapes consisting of aluminum silicate fibers and high temperature binders have also been developed. Table 3 lists properties of a typical board.

Several applications for these molded products are being investigated. Among them are re-usable risers for nonferrous casting—attractive because the riser would not be wetted by molten aluminum or magnesium. Also of interest: combustion chamber liners, baffles and flame deflectors, small furnace and oven liners, and can setter plates and shields. Corrugated sheeting serves as spacers in high temperature absolute filters and may be adaptable to base plates for heating element wires.

Impregnated moldings — Rigid, molded ceramic fiber products, because of their relatively high porosity, can be impregnated by vacuum and immersion techniques with commonly available inorganic binders, as well as rubber, phenolic, epoxy and silicone solvent or latex-base materials. Electrical and physical properties of such composites depend to a great extent on the materials used for impregnation.

Future Applications?

Here are some potential applications for aluminum silicate fiber in the future:

1. **Smog control.** It appears that much improvement in control of smog can be accomplished by incinerating waste materials at higher temperatures than are now customary. Even raw sewage when burned at temperatures above 1400 F produces no objectionable odors or air contaminants. Aluminum silicate fibrous insulation can provide sufficient protection to permit burning such waste at these elevated temperatures.

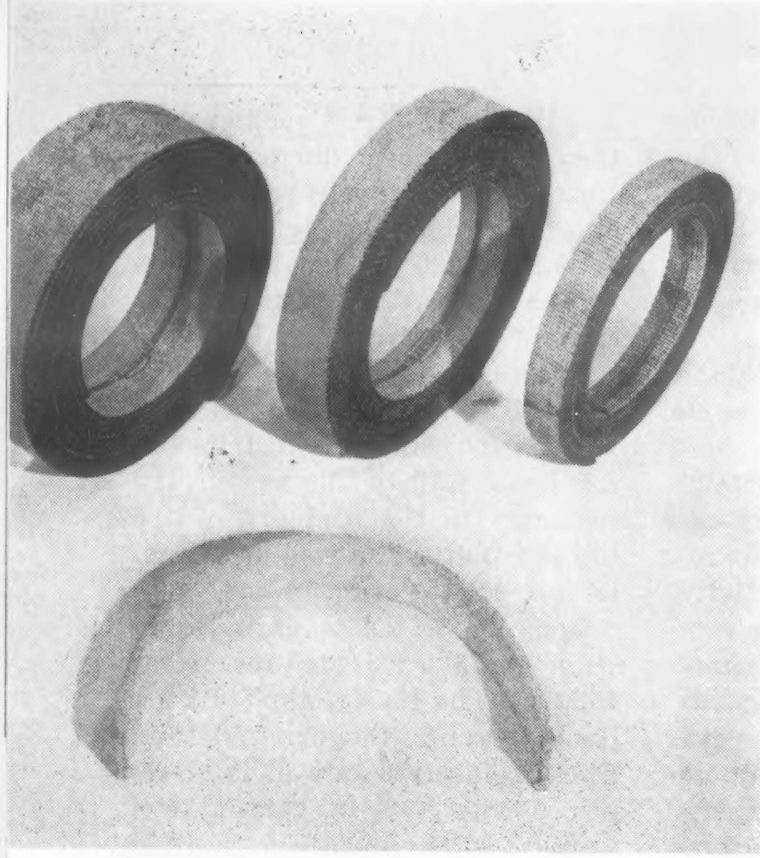
2. **Filtration of radioactive particles.** The fiber is being evaluated for filtration of radioactive particles from hot gas streams. Results to date indicate efficiencies are sufficient to meet the rigid safety requirements of atomic energy work.

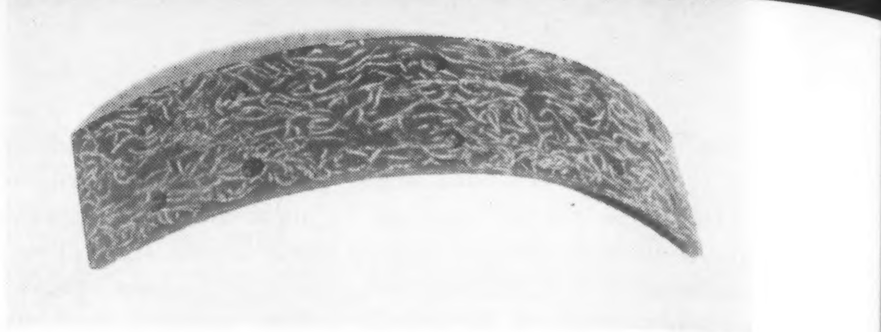
3. **Missiles.** The lightweight fiber may solve many of the problems of insulation and resistance to erosion and thermal shock encountered in rockets and guided missiles.

4. **Fire resistant products.** The extreme resistance to fire provided by aluminum silicate fibers suggests uses in manufacturing fireproof safes, files, desks and other office equipment, as well as fireproof panels for building construction and partitions.

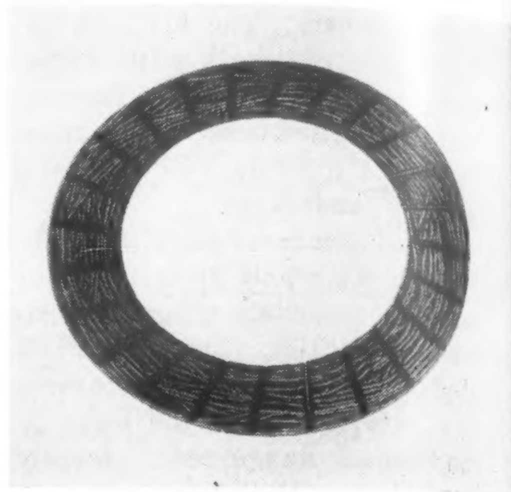
Acknowledgments

The author wishes to acknowledge the valuable assistance of co-workers J. C. McMullen, C. B. Perry, W. J. Lillis and others for technical assistance in the preparation of this article.





Rubberized
Rubber coated asbestos yarn is used for replacement brake lining (top) and Chevrolet clutch facing (right).



Woven *Friction materials composed of asbestos fibers and long staple cotton are shown before (bottom) and after (top) impregnation.*

Selecting Friction Materials

PART 1 | Selection factors

Woven, rubberized and molded materials

by Elwin J. Salter,
Supervisor, Friction Materials Laboratory, Inland Manufacturing Div., General Motors Corp.

■ It is obvious that no universal type of friction material could possibly satisfy the requirements of all brake and clutch designs. Since almost every design is unique and is used under different operating conditions, a number of friction materials have been developed for specific end uses. These materials include woven, rubberized, molded, resilient and metal-base types. With the exception of the woven and rubberized materials which are intended primarily for use in a dry or gas atmosphere, all of these materials can be operated dry or in an oil media.

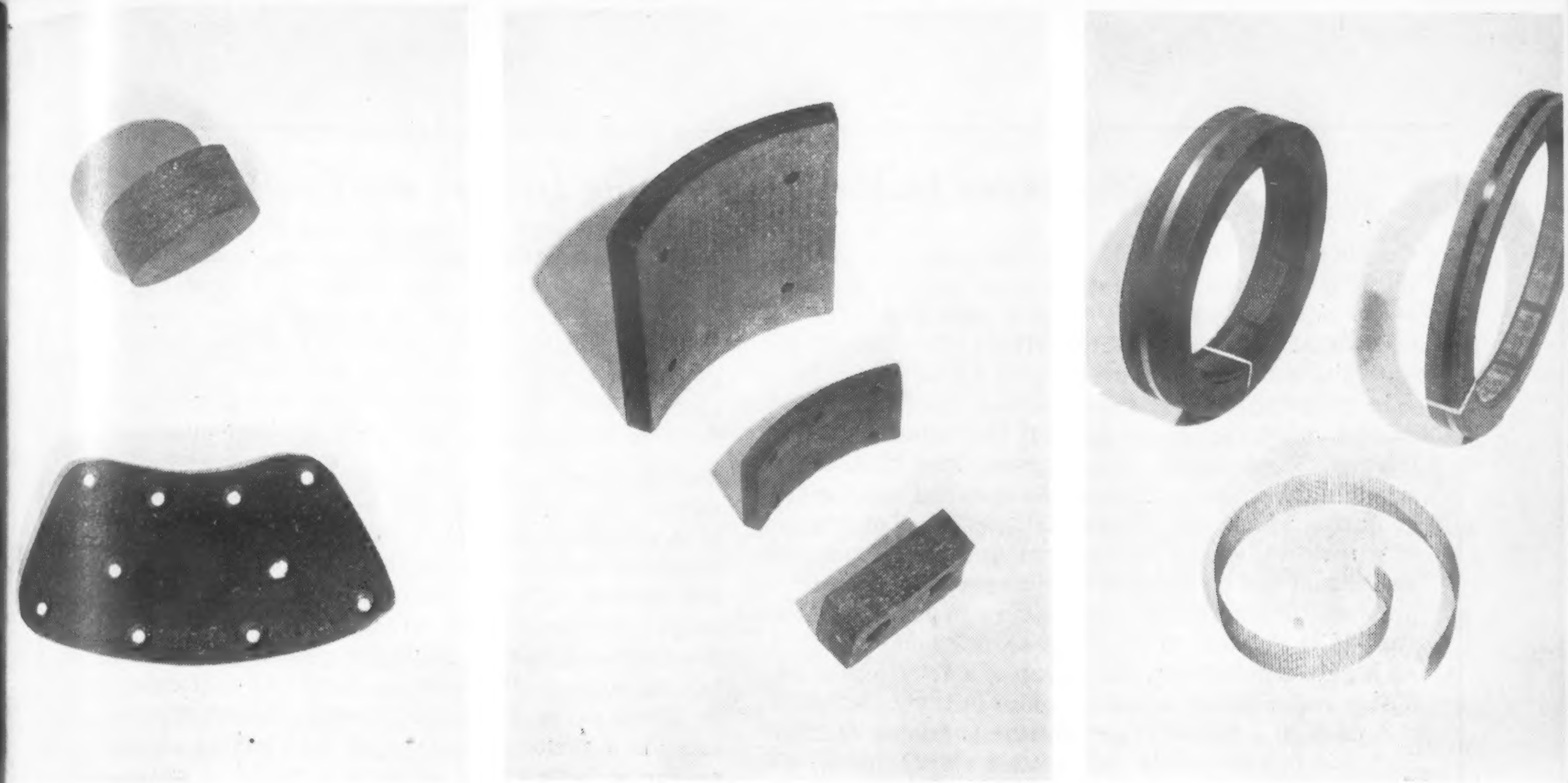
Woven materials

Woven friction materials are noted for their excellent engagement characteristics (due to high flexibility and resiliency) and their high coefficient of friction. The materials are particularly suited for, and are widely used in, industrial equipment. Their use in automotive equipment is comparatively small.

Essentially, woven materials consist of a weave of yarn and wire which has been impregnated, compressed to the required size, cured and coiled into a roll.

The yarn is composed primarily of long asbestos fibers of the chrysotile type plus a long staple cotton. The cotton aids in the spinning of the asbestos fibers, which are used principally because of their heat resistance and adaptability to weaving. The wire core, consisting of either brass or a lead–zinc alloy, serves to strengthen the yarn and improve frictional and wear properties. In some applications it may be omitted where the improvements in properties resulting from its use are not needed.

The impregnants may consist of drying oils, such as China Wood



Molded **Left**—*Extruded button type (top) and dry mix molded (bottom) friction materials are both used for disk brakes.* **Middle**—*Dry mix molded block (top) is used in brakes for trucks and trailers. Extruded block (center) and dry mix molded block (bottom) are both used in industrial applications.* **Right**—*Wire back lining in roll form. Section of wire screen backing is shown at bottom.*

Oil, linseed oil or castor oil; or thermosetting resins, such as oil modified and straight phenol formaldehyde resins, bitumens, or combinations of these. The asbestos fibers are difficult to impregnate; however, the cotton fibers aid in getting the saturant into the center of the lining.

Rubberized materials

Folded (laminated) and compressed fabric materials possess good wear resistance and relatively high frictional properties. They can be used for clutch facings as well as brake linings. Rivet holes can be incorporated directly by curing the materials in dies containing suitable projections. The materials are not recommended for very severe operating conditions involving high temperatures, as the laminated linings may deform and the outer layer(s) strip off under the action of the rotating drum.

Next Month

This is the first of two articles intended to aid the engineer in selecting friction materials for automotive, aircraft and industrial equipment applications. The second article next month will discuss resilient and metallic types of friction materials and will include tabular data comparing the significant engineering properties of all the materials covered in the two articles.

The foundation of folded and compressed friction materials usually consists of a square weave, single ply, asbestos-cotton-brass wire fabric. A basket, or twill, weave is occasionally used in place of the square weave. The cloth is usually woven from 40 to 60 in. wide and from 100 to 200 yd long. After weaving and drying, the cloth is impregnated with an asphaltic and bituminous waterproofing solution.

A rubber friction compound is bonded to the cloth foundation by means of calendering rolls which press the compound into the space in the fabric. The calendered cloth is approximately 1/16 in. thick and is plied or folded in layers to the required thickness (usually ¼ in. max). It is then cured under heat and pressure to vulcanize the rubber compound in the cloth structure.

Rubber coated yarn can also be used for clutch facings. The yarn is the same as that used in woven friction materials. Two or three strands are entwined and then dipped in a viscous rubber cement which is dispersed with a suitable filler. After drying to remove the cement solvents, the coated yarn is wound into an annular ring and cured in molds (which may incorporate grooves) under heat and pressure to form the clutch facing.

Molded materials

Dry mix molded friction materials are very rigid, are extremely heat stable, and possess good wear properties and engagement characteristics. Coefficient of friction varies from low to high depending on the compounding used, but is usually in the low to medium range. The materials have a tendency to fade at high temperatures, but usually recover quickly. They are particularly suited for use as brake blocks for heavy duty service, as well as for brake linings and clutch facings.

The dry molding compound consists primarily of medium and short asbestos fibers, plus suitable fillers, friction modifying constituents and a thermosetting straight

Consider these factors in selecting friction materials

Coefficient of friction is a useful gage for comparing friction materials. Materials are usually classified as having a low, medium or high coefficient. The coefficient of friction of automotive brake linings, for example, varies from low to high—0.2 to 0.5.

In selecting the optimum friction material, consideration must be given to: 1) the required initial friction, 2) operating temperatures, and 3) the permissible variation in friction the material may undergo during operation. Ideally, the coefficient of friction of a material should be constant under all conditions and should not be affected by changes in temperature, pressure or severity of application. In practice, however, it is difficult to obtain good frictional stability. At high temperatures, for example, most friction materials suffer either a loss or a rise in their coefficient.

A drop in a material's coefficient is known as "fading" and is responsible for reduced effectiveness. All organic materials will fade under severe use, but are considered satisfactory if they recover to their original state upon cooling. A rise in a material's coefficient is known as "build-up" and often results in a grabby action.

Wear is another important selection factor and is directly associated with the structure of a material and its operating temperature. Because of their excellent heat stability, phenolic-bonded materials possess excellent wear properties at high operating temperatures. Bonded materials using other than a phenolic binder are limited by their lower heat capacity; however, these materials will yield good life if operating temperatures are kept below the critical temperatures of the materials.

Phenolic-bonded materials also possess good wear characteristics under severe unit pressure loadings. Under these conditions, materials with lesser structural strengths—such as millboard, wireback and extruded materials—may wear at a high rate and produce objectionable dust.

Smooth operation may or may not be an important design factor. In general, engagement characteristics vary with the flexibility of the material. Thus, resilient and flexible woven materials possess better engagement characteristics than the semirigid and rigid types. These materials also have the ability to conform to an irregular shape.

Noise, likewise, may or may not be a critical design factor. In some industrial and aircraft applications it is not too important; however, it can be a critical factor in automotive applications. Irregularities in the surface of rigid materials have been found to cause vibrations which produce objectionable sounds. Resilient and flexible materials generally operate at a low noise level. However, no hard and fast rules can be given as to a material's noise characteristics; if noise is a factor some type of field testing should be conducted before final selection is made.

Noises can be classified by their frequency and quality as "grunt," "chatter" and "squeal" sounds. In general, grunt and chatter noises are not as objectionable as squeal sounds, which are high pitched and discordant.

Water sensitivity can be an important factor if it has an effect on a material's frictional characteristics. Excessive moisture in automotive brakes, for example, can produce noise or erratic action. This condition can be controlled by incorporating suitable compounds in the friction materials which mitigate the effects of moisture and control the formation of iron oxides on drum surfaces.

Cost is an especially important consideration in high volume applications such as automobile parts. Labor costs for reinstallation are important in industrial applications, and the correlation between a material's life and its initial cost must be carefully weighed. In general, the phenolic-bonded and metallic friction materials are the highest priced.

or modified phenolic bonding resin. Mechanical strength of the materials is in large part due to the extension of the asbestos fibers in all directions.

During fabrication, the stock is placed in a plunger type mold and formed into a biscuit. The biscuit is then placed into another mold to be formed into a brake block, or placed between press platens to be formed into flat sheets. Compressibility of the material ranges from 2 to 5 depending on whether the stock is first preformed into a biscuit or placed directly in the mold. After forming, the mixture is cured at 1000 to 3000 psi and 250 F. Final baking is at 400 F.

Extruded type friction materials are basically similar to the dry mix type except for the use of a liquid bonding agent. They have a good appearance but tend to be structurally weak. However, strength can be improved by using thermosetting bonding resins and controlled curing. Heat stability is not as good as that of dry mix linings. Coefficient of friction ranges from low to high, depending on composition.

The bonding agent for extruded linings may consist of straight or modified phenolic resins, oils, natural or synthetic rubbers, or any combination of these materials. A solvent is used to promote dispersion. The ingredients are mixed and blended into a soft and plastic stock which is fed into a standard extruding or tubing machine. Curing is accomplished after the extruded stock has been cut and formed into the required shape.

Wire back type linings possess good frictional properties and, under normal conditions of brake operation, have an acceptable wear rate. However, they are not as heat stable as dry mix materials and often fade badly. Wire back linings are quite popular as re-

placement linings and are also used as original equipment on some automobiles. Because of their weak structure they are not suitable for heavy duty applications or for clutch facings.

The wire backing serves a twofold purpose. During manufacturing it strengthens the fabricated but uncured lining stock, which would otherwise be very fragile and difficult to handle. Also, it strengthens the finished lining and improves resistance to the shearing action of rivets during severe braking.

Aside from the wire backing, these linings are quite similar in composition to extruded linings. Their chief constituents are short length asbestos fibers and a binder which may consist of drying oils, natural or synthetic rubber, thermosetting straight or modified phenolic resins, or any combination of these. Balance of the mixture consists of fillers and friction modifiers.

The ingredients are mixed into a homogeneous plastic composition and pulverized into small particles. The pulverized stock is fed between rolls which compact the material and form it into continuous strip. The wire screen backing is carried around one of the rolls and embedded into the friction material. (The wire screen backing is sometimes eliminated to produce an unreinforced lining material which is known as "roll molded.") The formed strip is then cured in long lengths or individual segments. In some applications the wire cloth can be omitted to produce an unreinforced lining material which is known as "roll molded."

Sheeter type friction materials are made by laminating thin films of a rubber bonded matrix. They are relatively expensive but have good frictional and wear properties. These materials are used primarily for industrial brake linings and clutch facings. They are not ordinarily used for automotive brake linings, as their heat resistance is not as good as that of some other materials.

American Brakeblok Div., American Brake Shoe Co.

Wire back lining *shown just after screening has been embedded in friction material.*

Ingredients of the material consist of medium and long length asbestos fibers, fillers, friction modifiers, and natural or synthetic rubber in cement form. The stock is fed between two rolls, of which one is kept hot and the other cold. The stock adheres to the hot roll and forms a thin film 1 to 2 mils thick. As the rolls rotate, additional layers are built up on the hot roll to the required thickness, which is controlled by the distance between the rolls.

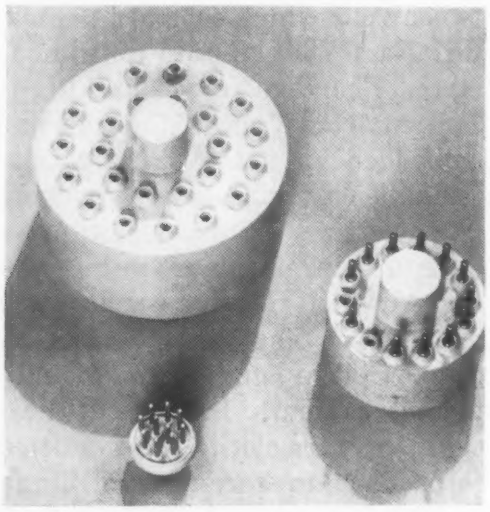
After forming, the sheet is removed from the hot roll and cut to shape. The cut stock is then dried, cured under heat and pressure, and ground to specified dimensions.

Millboard friction materials possess wear and high temperature properties which are not as good as those of some of the other molded materials. However, they do have good engagement characteristics. Frictional stability is often poor because of non-uniform impregnation. The materials are used chiefly in industrial clutches.

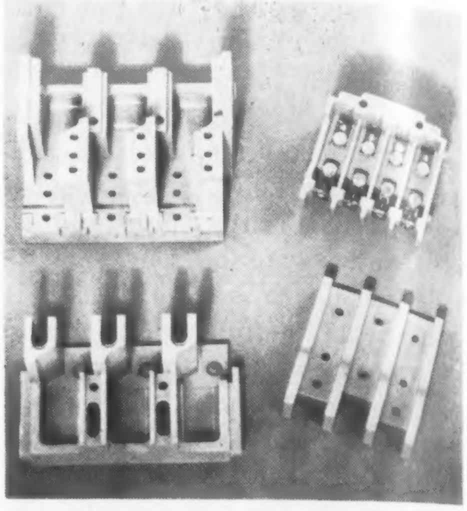
Millboard is composed primarily of long asbestos fibers. The fibers and compounding materials are placed in a large vat of water and beaten to a pulp. The pulp is then fed to a paper making machine and formed into a thin sheet (which can be laminated) which is cut to approximate dimensions and then dried and impregnated. After impregnation the blanks are baked and ground to size. Impregnants used may consist of thermosetting resins, drying oils, bituminous materials, or combinations of these. Difficulties are encountered in obtaining complete impregnation and in incorporating friction modifiers into the millboard. Modifier particles with a low specific gravity can be added directly to the pulp only when the asbestos has enough body to support them. Particles with a high specific gravity may have to be spread on the forming roll of the millboard machine so that they can be picked up by the asbestos sheet as it passes through.

Alkyd Moldings for Electrical Uses

Granular compounds are used for . . .

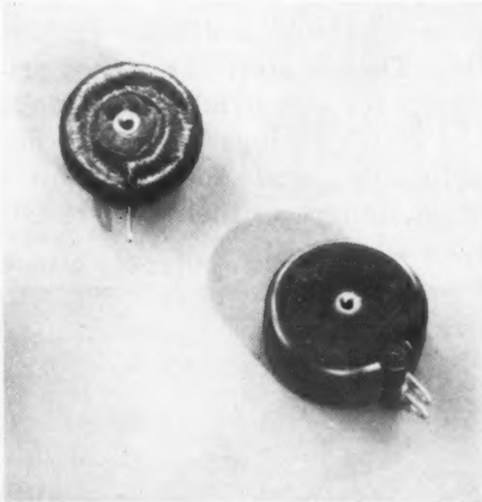


Vacuum tube bases

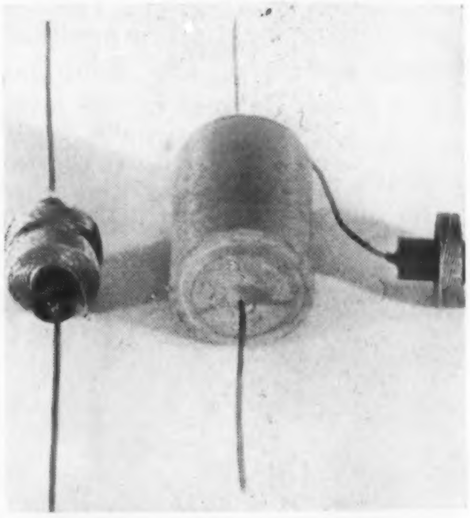


Power circuit insulation

Putty is used for encapsulating . . .



Toroidal coils



Pie wound coils

These plastics are finding increasing use in electrical and electronic components. Here are some of the newest applications for alkyds, together with helpful data on the three major types of compounds.

by J. T. Long, *Barrett Div., Allied Chemical & Dye Corp.*

■ Alkyds are primarily used for electrical applications. They have inherently excellent dielectric properties over a relatively broad temperature range, plus excellent dimensional stability. They can be molded with relatively low pressures and, with proper reinforcing materials, they can provide high mechanical strength.

Three types of alkyd molding compounds are generally available:

1. *Granular types* have mineral or modified mineral fillers which provide superior dielectric properties and heat resistance.

2. *Putty types* are soft and particularly well suited for low pressure molding.

3. *Glass-reinforced types* have superior mechanical strengths.

Typical properties of the three types are shown in the accompanying box. The applications discussed in the following sections of the article indicate the uses for which each type of molding compound is best suited.

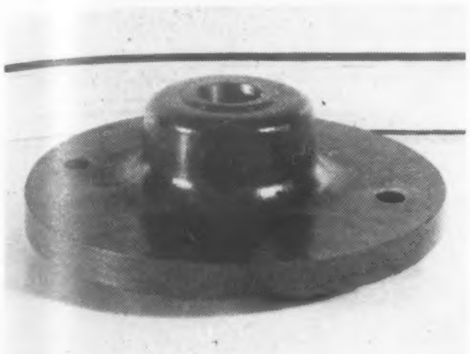
Granular types

Because of the free-flowing powder form in which mineral-filled granular alkyd molding materials are supplied, they can be used in automatic molding presses or preform machines. They have the same fast curing characteristics and low pressure requirements common to all alkyd materials.

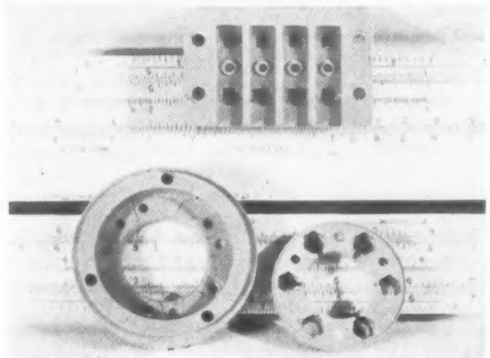
Vacuum tube bases—One of the major electronic applications for granular alkyd compounds is vacuum tube bases. The high dry insulation resistance of the material is particularly useful in special tube bases where the electrical leakage between pins must be kept to a minimum.

Automotive ignition—Retention of good dielectric characteristics at relatively high temperatures has caused alkyds to be used in a variety of applications in car ignition systems—particularly with the current trend toward higher engine compression ratios, and the resulting higher temperatures to which ignition systems are exposed.

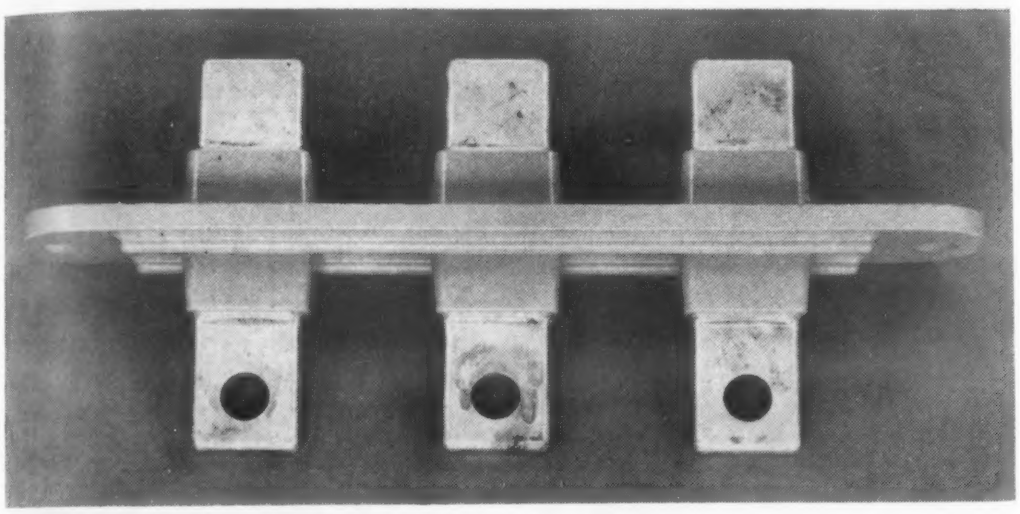
Glass-reinforced compounds are used for . . .



Mobile antenna mounts



Syncro and servo parts



Switchgear components

Alkyds and Polyesters

There has been a good deal of confusion in nomenclature when discussing alkyd and polyester resins. Actually, any reaction product of a polybasic acid and a polyhydric alcohol is a polyester. Although alkyd resins used in coating formulations are polyester resins modified with fatty acids, the resins used in so-called "alkyd molding compounds" are unmodified, polymerizable polyester-type resins. Thus, by chemical definition, alkyd molding compounds can correctly be called polyesters.

Actually, the selection of the words alkyd or polyester is determined pretty much by common usage. There has been a growing trend toward use of the two interchangeably. At present, polyester resins used for casting or laminating are called polyesters. Polyester resins used for molding are generally called alkyds.

A typical example of the use of alkyds in ignition systems is a molded ignition coil top, where dielectric strength at elevated temperatures, as well as arc resistance and dimensional stability, are desirable. Another application is a spark plug lead insulator, where high heat resistance and dielectric strength are required.

Power circuit insulation—Mineral-filled granular alkyd materials are used for power circuit control parts, such as components of motor starters, circuit breakers and switchgear; and for teminal strips and bus bar supports.

Putty types

In general, putty type alkyd molding compounds are extruded into ribbons of specific size before molding. Because of their softness, these compounds are particularly useful in molding around delicate inserts or where difficult mold loading problems exist. One of their major uses is in compression molded encapsulation of small electronic components where dielectric loss characteristics are of prime importance.

Capacitors and resistors—Alkyd putty is used in the encapsulation of capacitors and resistors because it provides excellent electrical insulation for the component as well as providing a satisfactory moisture seal.

Toroid and pie-wound coils—Proper encapsulation of toroid coils has always been a problem because of difficult mold loading problems. Recently several small companies have developed methods for successfully encapsulating such coils with putty type alkyd materials.

Similarly, molded encapsulation of pie-wound coils has long been considered impractical because of their fragility. With the development of a special spring-loaded mold, unique in that no press is used, B. J. Toegel Laboratories has successfully encapsulated these coils with alkyd putty.

Upright capacitors — Upright capacitors, similar to standard paper capacitors except that both leads emerge from one end of the molded unit, are now encapsulated with alkyd putty. The low molding pressure required to form alkyd putty contributes to the success of this operation.

Glass-reinforced types

These materials have found widespread use in applications where a combination of high strength, superior dimensional stability, good electrical properties and heat resistance is important. They can be readily plunger or compression molded.

Probably the major use for glass-reinforced alkyd compounds has been in defense equipment, such as Navy shipboard circuit breaker and switchgear installations. Since Naval equipment must function under shock conditions caused by gunfire, the high impact strength of reinforced alkyds is obviously advantageous.

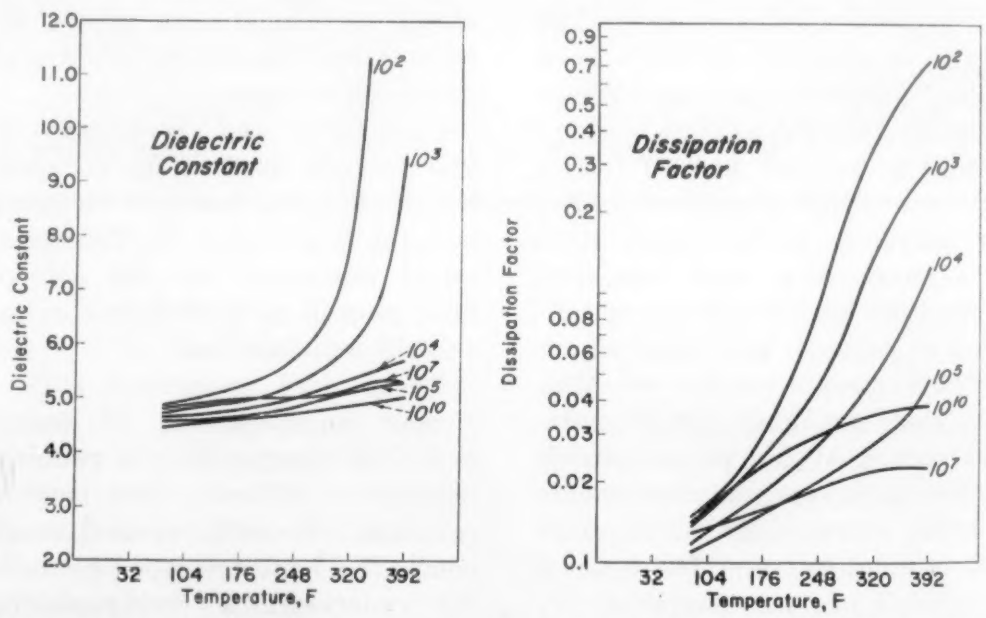
Mobile antenna mount—Reinforced alkyd has replaced porcelain in molded antenna mounts

Properties of molded alkyds—a comparison of seven types

Type and Primary Requirement[a] ➡	Granular			Putty		Reinforced	
	General Purpose	Low Moisture Absorption	Light Weight	Light Weight	Low Moisture Absorption	High Impact	Medium Impact
ELECTRICAL PROPERTIES							
Dielectric Constant							
60 CPS	6.0-6.5	6.0-6.5	6.9-7.2	5.9-6.5	5.8-6.2	5.2-6.0	7.0
1 Megacycle	4.8-5.0	4.2-4.5	5.5-5.7	4.4-5.0	4.4-4.6	4.0-4.5	5.9
Dissipation Factor							
60 CPS	0.050-0.060	0.035-0.040	0.050-0.070	0.040-0.050	0.035-0.040	0.02-0.03	0.02-0.04
1 Megacycle	0.016-0.018	0.014-0.015	0.035-0.040	0.025-0.035	0.014-0.017	0.017-0.022	0.015-0.018
Dielectric Strength, v/mil							
Short Time	350-400	350-400	350-400	350-400	350-400	350-400	350-400
Step-by-Step	300-350	300-350	300-350	300-350	300-350	300-350	300-350
Arc Resistance	180	180	180	140	180	180	130-160
PHYSICAL PROPERTIES							
Specific Gravity	2.22-2.24	2.16-2.18	1.95-1.98	1.81-1.91	2.05-2.15	2.00-2.08	2.2-2.3
Compressive Strength, psi	16,000-20,000	18,000-21,000	21,000-24,000	18,000-24,000	18,000-24,000	24,000-28,000	26,000-31,000
Tensile Strength, psi	3,000-4,000	3,000-4,000	3,500-4,500	3,000-4,000	3,000-4,000	6,000-10,000	5,200-6,200
Flexural Strength, psi	7,000-10,000	7,000-10,000	8,000-10,000	8,000-10,000	8,000-10,000	14,000-17,000	12,000-16,000
Impact Strength (Izod), ft-lb/in.	—	—	—	—	—	8-12	2-3
Water Absorption							
(24 hr, 73 F), %	0.08-0.10	0.04-0.06	0.55-0.60	0.13-0.15	0.05-0.08	0.07-0.10	0.18-0.22
Max Rec Svc Temp, F							
Long Period	300	275	250	250	250	300	300
Limited Period	350	300	275	300	300	350	350
Short Period	375	325	300	325	325	400	400
Self-Extinguishing	No	Yes	No	Yes	Yes	Yes	Yes

[a]The differences between various compounds of the same type are relatively small. Classification by primary requirement is made only to indicate the major outstanding property of each compound in each type.

The table lists typical properties of of various types of alkyd molding compounds. Most outstanding are the excellent dielectric characteristics coupled with the relatively good heat resistance. The effects of temperature on these dielectric properties are indicated by the accompanying curves. Notice that at radio, television and UHF frequencies, the rise of dielectric constant with temperature is relatively slight; at 400 F, dielectric constant is still less than 6.0. The rise in dissipation factor with temperature is also relatively slight at the higher frequencies, remaining under 0.05 at temperatures up to 400 F.



Electrical properties *vs temperature for typical mineral-filled alkyd compound at various frequencies (von Hippel.)*

used for tanks, trucks, armored cars and other types of mobile military equipment. These mounts weigh between 1 and 2 lb. The combination of excellent dielectric properties and high impact strength is a principal reason for the choice of glass-reinforced alkyd.

Other uses—Reinforced alkyd compounds are also being used in applications such as computer components, circuit breakers, signal light and fuse holders, rocker rings, motor end bells, aircraft ignition parts, coil forms, blower housings and various types of switchgear parts.

Spray painting can now be safer with . . .

Water-Thinned Paints for Metal Products

Because of their nonflammability and low toxicity, water-thinned paints can markedly reduce the hazards involved in painting. This article describes a new group of styrene-butadiene latex formulations developed especially for metal surfaces.

Background

Until recently, development of suitable water-thinned paints for metal surfaces has been held back because of corrosion problems, lack of adhesion and low gloss. In the past two or three years, however, a limited number of water-thinned paints have been made available, including those based on acrylic emulsions and polyvinyl acetate resins. This article describes a new group of styrene-butadiene paints—one of the most promising group of water-thinned paints developed to date for metal surfaces.

■ In the past ten years water-thinned latex paints have achieved considerable popularity for decorating and protecting interior surfaces and masonry. They have gained wide consumer acceptance because of their ease of application, low odor and fast drying characteristics, and ease of equipment clean-up.

To designers of metal products the most appealing property of water-thinned latex coatings is that they are not flammable and can be applied without any fire hazard. To date, a limited number of these coatings have been made available for engineering applications. The newest, and among the most promising, water-thinned formulations to be put into commercial production are based on a new styrene-butadiene latex, Dow Latex 566, developed by the Dow Chemical Co. especially for metal surfaces. Formulations based on the new latex completely retain the nonflammability and other desirable characteristics of conventional formulations, yet do not cause corrosion on metal surfaces.

Properties

Like any latex system, the new styrene-butadiene latex is a colloidal dispersion of resin particles in a water system. This fact is of particular significance to the user, since it virtually eliminates the hazards of solvent toxicity and flammability. The latex is supplied at an acid pH. By means of heat and catalysis the butadiene groups in the polymer react to form a thermosetting coating with excellent adhesion, toughness and hardness, and resistance to water, mineral spirits and some chemicals.

Properties of clear styrene-butadiene latex coatings are compared with those of other organic coatings in Table 1. As shown, the properties of baked coatings are excellent for a water-based system. Despite their hardness after baking (3H-5H Pencil Hardness), the coatings possess excellent adhesion and exhibit good flexibility when flexed over a ⅛-in. mandrel. Also, since the styrene-butadiene resin particles have a high molecular weight, it is possible to formulate paints with a high solids content, thereby insuring high film thickness per coat.

Clear coatings, which generally exhibit poorer impact resistance than pigmented coatings, have shown an impact resistance of less than 2 in.-lb. However, the impact resistance of pigmented

automotive primers is comparable to that of standard alkyd primers.

Automotive, appliance primers

The potential applications of a latex coating system for metal surfaces are numerous and diverse. As a starting point experimental primer formulations have been developed for automotive and appliance applications.

Both of the two automotive baking primers described in Table 2 below—pigmented with iron oxide and iron oxide-zinc yellow, respectively—have exhibited:

1. Excellent spraying characteristics.

2. Excellent adhesion and sand-

TABLE 1—NEW LATEX PAINT VS OTHER CLEAR ORGANIC COATINGS[a]

Coating Vehicle ➡	Styrene-Butadiene Latex		Acrylic Emulsion	Polyvinyl Acetate Emulsion (internally plasticized)	Short Oil Alkyd Emulsion	Short Oil Soya Alkyd Resin	Medium Oil Soya-Tung Alkyd Resin	Short Oil Alkyd-Urea Formaldehyde Resins (90:10)
APPLICATION CONDITIONS								
pH	4	8	9	4	7	—	—	—
Catalyst	None	0.07% Co	None	None	0.1% Co	0.03% Co	0.03% Co	None
Bake	275 F, 30 min	275 F, 30 min	350 F, 30 min	300 F, 30 min	300 F, 30 min	300 F, 30 min	300 F, 30 min	300 F, 30 min
MECHANICAL PROPERTIES								
Knife Adhesion	Excellent	Excellent	Good	Fair	Good	Fair to Good	Fair to Good	Fair to Good
Flexibility over ⅛-In. Mandrel	Crazed	Crazed	OK	OK	OK	OK	OK	OK
Impact Resistance, in.-lb	<2	<2	>28	>28	<2	>28	>28	>28
Pencil Hardness	5H	3H	H	4B	F	HB	HB	HB
CHEMICAL PROPERTIES								
Resistance to Mineral Spirits, 1 hr	OK	OK	OK	OK	OK	OK	OK	OK
Water Resistance								
1 Hr	OK	OK	Whitened, sl loss of adhesion	Badly whitened, loss of adhesion	Whitened, sl loss of adhesion	Sl whitened	Sl whitened	OK
24 Hr	Sl whitened	OK	Badly whitened, loss of adhesion	Badly whitened, loss of adhesion	Badly whitened, brittle	Sl whitened, sl loss of adhesion	Sl whitened, sl loss of adhesion	OK
1 Wk	Whitened, sl blistered	Sl whitened, sl blistered	Bad loss of adhesion	Bad loss of adhesion, rust	Badly whitened, brittle	Whitened, sl blistered	Loss of adhesion, blistered	OK
Res to 3% Sodium Hydroxide								
1 Hr	OK	Sl brittle	Lifted	Lifted	Sl soft	OK	OK	OK
24 Hr	OK	Sl brittle	—	—	Dissolved	Dissolved	Dissolved	Badly softened
Resistance to 5% Acetic Acid								
1 Hr	OK	Brittle	Whitened	Loss of adhesion	Soft	OK	Very soft	Very soft
24 Hr	OK	Brittle	Lifted	Lifted	Blistered, brittle	Loss of adhesion, blistered	Loss of adhesion, blistered	Loss of adhesion, blistered

[a]Basis metal: cold rolled steel.

TABLE 2—TYPICAL LATEX FORMULATIONS FOR METAL SURFACES

Type ➡	Iron Oxide Automotive Primer	Iron Oxide-Zinc Yellow Automotive Primer	White Appliance Primer	Dark Gray Gloss Enamel	Gray Semigloss Enamel
Pigment, %	Iron oxide.....25 China clay.....25 Barytes........50	Iron oxide..........48 Zinc yellow........26 Magnesium silicate. 26	Rutile TiO_2.....40 Barytes........35 Zinc oxide.....25	Rutile TiO_2...95.6 Carbon black..4.4	Rutile TiO_2........76 Black iron oxide...24
Binder					
Styrene-Butadiene Latex, %	100	100	100	95	95
Ceremul R, %	—	—	—	5	5
Pigment: Binder Weight Ratio	1:1	1:1	1.5:1	1:5	1:3
Solids by Weight, %	56	55	55	48	49
Total Weight, lb/gal	9.9	10	11.3	8.8	9.3
Viscosity (No. 4 Ford cup), sec	13	13	14	14	13
pH (adjusted with NH_4OH)	9	7.5	7.2	5.4	5.2

ing properties.

3. Good enamel hold-out.

4. Salt spray resistance of 340 hr minimum for the complete primer-enamel system.

5. Impact resistance, before and after salt spray exposure, comparable to that of alkyds.

Both primers are applied on phosphate treated steel. Film thickness and baking schedules differ slightly. Dry film thickness is 1.8-2.2 mils for the iron oxide primer and 1.2-1.5 mils for the iron oxide-zinc yellow primer. The iron oxide is usually baked 30 min at 275 F and the iron oxide-zinc yellow 30 min at 325 F. Both primers are wet sanded with No. 320 sandpaper before topcoat application.

A typical formulation for a white appliance primer based on the styrene-butadiene latex is also shown in Table 2. This formulation sprays easily (1.0-1.2 mils) and can be covered with a white appliance baking enamel topcoat after a short flash (10 min) bake at 140 F. Sanding is not necessary.

After enamel baking, the primer has exhibited excellent adhesion and excellent enamel hold-out, and has successfully withstood exposure in a 100% RH, 100 F atmosphere for 1000 hr. Care should be taken to stabilize the latex with additional surface activators if zinc oxide pigments are used. Stability of the system is good at room temperatures but should be checked after severe handling and storage conditions. Also, the system should be protected against freezing temperatures.

Baking enamels

Both gloss and semigloss baking enamels can be formulated with the styrene-butadiene latex. In gloss enamels:

1. Compared to conventional organic coatings, a higher vehicle-to-pigment ratio is required to obtain a high gloss.

2. Even with pigments having high hiding power, the latex does not have sufficient color retention at elevated temperatures to permit its formulation in white or light colored coatings.

3. The acid pH results in a problem of iron staining; however, an acid system generally provides a harder, more mar resistant, gloss coating than an alkaline system.

4. Hardness and mar resistance can be further improved by incorporating waxes, such as Ceremul R, and by using high baking temperatures.

Semigloss coatings using a styrene-butadiene latex are essentially the same as gloss coatings but are formulated with a higher pigment content. Pigment content can be raised either by increasing the prime pigment or by using an extender such as calcium carbonate.

Formulation fundamentals

Styrene-butadiene latex paints are similar to conventional resin solution paints in that they are composed essentially of pigment, nonvolatile vehicle, volatile vehicle and additives. Specific ingredients of the paints differ; however, many of the pigments used in resin solution paints and other latex paints can also be used with the new styrene-butadiene latex.

Rutile titanium dioxide is the most effective of the white hiding pigments. Lithopone is suitable for most conditions but must usually be used in conjunction with titanium dioxide for adequate hiding power. Some of the extender pigments that can be used with the styrene-butadiene latex include: clays, magnesium silicates, calcium carbonates (water washed), silica, diatomaceous silica, mica and barytes.

Color pigments for use with the latex can be chosen from three different types: 1) dry pigments used in oil paints; 2) aqueous pigment dispersions; and 3) treated dry pigments for latex use. Both inorganic and organic pigments are available in each of these types. Typical of the inorganic pigments that can be used are: iron oxides (natural and synthetic), burnt sienna and burnt umber, ultramarine blue, cadmium red, orange and yellow, chromium oxide hydrate, and zinc oxide and chromate. (Zinc oxide and chromate can be used up to 25 to 30% pigmentation, but require surface activators to prevent coagulation.) Typical organic pigments include: naphthol red, toluidine red, phthalocyanine blues and greens, pigment green B, carbon black and Hansa yellow.

How the Coating Forms

Essentially, the solid portion of the latex formulation consists of the styrene-butadiene latex or binder and a water dispersed pigment, plus suitable modifiers. The solids are made up of very small particles. During drying, the film forms by a two-step process: 1) evaporation of the water, followed by 2) fusion of the resin particles, which occurs as surface tension forces the spherical resin particles to flow together. The resin particles fuse around the pigment particles and occlude them in the film.

Heat and catalysts play an important part in the development of successful films. At the pH of 4.0±.5 at which the latex is supplied, a sufficient number of iron ions are formed from ferrous surfaces to catalyze the butadiene double bond. This action produces a thermosetting, cross-linked structure.

The latex system can also be catalyzed by introducing metal catalysts through their water soluble or water dispersible compounds. This form of catalysis is usually necessary on nonferrous surfaces (such as aluminum and magnesium) which do not contain any iron, or when the pH of the latex system is forced into the alkaline range. Catalysis under this condition can be obtained with either the water soluble acetate salts of cobalt and manganese or the water dispersible grades of cobalt and manganese naphthenate. Iron salts can also be used but they are not as effective as cobalt and manganese catalysts.

Type ➡	Corrosion Resistant Irons			Heat Resistant Irons				
						High Nickel		
	High Silicon	High Chromium	High Nickel	High Silicon	High Chromium	Ni-Resist	Nickel-Chromium-Silicon	High Aluminum
COMPOSITION (%)	C 0.4-1.0 Si 14-17 Mn 0.4-1.0 Mo 0-3.5	C 1.2-2.5 Si 0.5-2.5 Mn 0.3-1.0 Ni 0-5 Cr 20-35	C 1.8-3.0 Si 1.0-2.75 Mn 0.4-1.5 Ni 14-30 Cr 0.5-5.5 Cu 0-7 Mo 0-1	C 1.6-2.5 Si 4.0-6.0 Mn 0.4-0.8	C 1.8-3.0 Si 0.5-2.5 Mn 0.3-1.5 Ni 0-5 Cr 15-35	C 1.8-3.0 Si 1.0-2.75 Mn 0.4-1.5 Ni 14-30 Cr 1.75-5.5 Cu 0-7 Mo 0-1	C 1.8-2.6 Si 5.0-6.0 Mn 0.4-1.0 Ni 13-32 Cr 1.8-5.5 Cu 0-10 Mo 0-1	C 1.3-1.7 Si 1.3-6.0 Mn 0.4-1.0 Al 18-25
PHYSICAL PROPERTIES								
Density, lb/cu in.........	0.252-0.254	0.260-0.280	0.264-0.270	0.245-0.255	0.264-0.270	0.264-0.270	0.265-0.269	0.200-0.232
Coef of Ther Exp (rm temp), per °F................	6.7×10^{-6}	$5.2\text{-}5.5 \times 10^{-6}$	$4.5\text{-}10.7 \times 10^{-6}$	6.0×10^{-6}	$5.2\text{-}5.5 \times 10^{-6}$	$4.5\text{-}10.7 \times 10^{-6}$	$7.0\text{-}9.0 \times 10^{-6}$	8.5×10^{-6}
Elec Res, microhm-cm....	—	—	—	—	—	140-170	150-170	240
Magnetic Permeability....	—	—	—	—	—	—	—	—
Max Service Temp, F.....	—	—	—	1650	2000	1500	1740	2000
MECHANICAL PROPERTIES								
Tensile Strength, 1000 psi.	13-18	30-90	25-45	25-45	30-90	25-45	20-45	34-90
Yield Strength (0.2% offset, 1000 psi).........	—	—	—	—	—	—	—	—
Elongation, %............	—	—	—	—	—	—	—	—
Hardness, (Brinell).......	450-500	290-400	100-230	170-250	250-500	130-250	110-210	180-350
Impact Strength, ft-lb[a]....	2-4	20-35	60-150	15-23	20-35	60-150	80-150	—
Transverse Strength, lb[b]..	1200-1600	2000-3500	1800-3000	1000-2400	2000-3500	1800-3000	1800-2500	—
Deflection, in.[b]..........	—	0.06-0.15	0.20-1.0	0.18-0.35	0.06-0.15	0.20-1.0	0.30-1.40	—
Compressive Strength, 1000 psi.............	—	100	100-160	90-150	100	100-160	70-100	—

[a]1.2-in. dia unnotched bar broken on 6-in. supports. (Gray iron ranges from 25 to 35 ft-lb).
[b]Standard 1.2-in. dia bar loaded in center of 18-in. span.

Alloy Cast Irons Can Solve

Cast iron containing additions of nickel or chromium, or more silicon than usual, are widely used for:

- *Corrosion resistance*
- *Electrical resistance*
- *Heat resistance*
- *Low thermal expansion*
- *Nonmagnetic properties*

1. Corrosion resistant irons

Four alloying elements are generally used singly or in combination to enhance corrosion resistance in cast iron: silicon, nickel, chromium and copper. Silicon is normally present up to 3% in all cast irons, but in larger percentages it promotes the formation of a protective surface film under oxidizing conditions (such as exposure to oxidizing acids) and is considered an alloying element. Nickel improves resistance to reducing acids and has high resistance to caustic alkalis. Chromium assists in forming a protective oxide film, thus improving resistance to oxidizing acids, but it is of little benefit under reducing conditions. Copper improves resistance to sulfuric acid to a lesser extent.

A large number of corrosion resistant alloy irons with different alloy contents are available, but they may be considered under three general classifications:

1. High silicon cast irons with a ferritic matrix.

2. High chromium, ferritic cast irons.

HIGH ALLOY CAST IRONS

Special Purpose Irons		Ductile Irons		
Low Expansion	Magnetic & Electrical	High Silicon	High Nickel	Higher Nickel
C 2.40 max Si 1.0-2.0 Mn 0.4-0.8 Ni 34-36 Cr 0.1 max Cu 0.5 max	C 3.00 max Si 1.0-2.5 Mn 0.8-1.5 Ni 13.5-22 Cr 1.75-2.50 Cu 0-7.5	C 2.8-3.8 Si 2.5-6.0 Mn 0.20-0.60 Ni 0-1.5	C 2.90 max Si 1.75-3.2 Mn 0.8-1.5 Ni 18-22 Cr 1.75-2.5	C 3.00 max Si 2.0-3.0 Mn 1.8-2.4 Ni 21-24 Cr 0.5 max
0.268	0.264	0.257	0.268	0.268
2.2×10^{-6}	$10.4\text{-}10.7 \times 10^{-6}$	$6.0\text{-}7.5 \times 10^{-6}$	10.4×10^{-6}	10.2×10^{-6}
160-170	140-170	58-87	102	—
—	1.03	—	—	—
—	—	1650	1300	1100
20-25	25-30	60-100	55-69	54-65
—	—	45-75	32-36	30-35
—	—	0.20	8-20	20-40
100-125	125-170	140-300	140-180	130-170
150	100	5-115[c]	12[d]	28[d]
1800-2000	2000-2200	—	—	—
0.5-1.0	0.3-0.6	—	—	—
80-100	100-120	—	—	—

[c]Standard Charpy test on 10-mm unnotched specimen.
[d]Standard Charpy test on 10-mm V-notched specimen.

Tough Problems

3. High nickel, austenitic irons, frequently containing copper or chromium.

High silicon irons

High silicon irons, commercially known as Duriron or Durichlor (with 3.5% molybdenum), are widely used for handling corrosive acids. With a silicon content of 14.5% or higher, these irons have high resistance to boiling 30% sulfuric acid. Increasing the silicon content to 16.5% is effective in reducing corrosion by boiling nitric and sulfuric acid at nearly all concentrations, although resistance varies somewhat with concentration. High silicon iron is not as effective against the corrosive action of hydrochloric acid, but resistance can be improved by the addition of 3.5% molybdenum and further enhanced by increasing silicon to 17%.

The high silicon irons are useful for solutions containing copper salts or free wet chlorine, but their resistance to strong hot caustics is not satisfactory for most purposes. These cast irons are resistant to organic acid solutions at any concentration or temperature, but are inferior to plain gray iron in resistance to alkalis.

The high silicon irons have poor mechanical properties; in particular, low shock resistance. They are difficult to cast and are virtually unmachinable. In spite of these disadvantages, their outstanding resistance to acid media has led to considerable use. They are the standard material for drain pipe in chemical plants and laboratories.

High chromium irons

The high chromium alloy cast irons (20 to 35% Cr) are similar in many aspects to the high silicon irons, since they give good service in oxidizing acids, particularly nitric, but are not resistant to reducing acids. These irons are also reliable in weak acids under oxidizing conditions, numerous salt solutions, organic acid solutions, caustic soda solutions and general atmospheric exposure. Chromium irons are complementary to high silicon irons in handling nitric acid; the former exhibit excellent corrosion resistance at all temperatures and concentrations except for boiling concentrated, whereas the latter yield better results in strong acid.

Frequently 30 to 35% chromium is used in irons for use under severe corrosive conditions, e.g., in pump impellers and housings for handling corrosive and abrasive slurries in the lead, aluminum and cement industries.

High chromium also improves heat resistance. The lower carbon grades of the highly alloyed irons are satisfactory for use in annealing pots, lead or aluminum melting pots, conveyor links and other parts exposed to corrosion at high temperatures.

Chromium cast irons have better mechanical properties than high silicon irons. Tensile strengths as high as 70,000 psi are obtained with a Brinell hardness range of 290-340. Chromium irons are resistant to shock and are machinable, but reducing carbon content to about 1.2% improves both of these properties.

Adapted from a section on the properties of white and high alloy cast irons, by J. H. Culling, vice president, Carondelet Foundry Co., St. Louis; and Prof. John F. Wallace, Case Institute of Technology, Cleveland, to be included in the Gray Iron Founders' Society's forthcoming *Iron Castings Handbook*, edited by Charles F. Walton.

High nickel irons

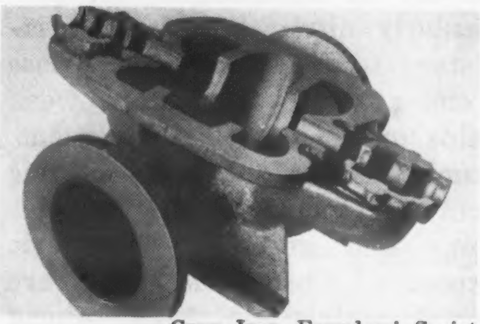
High nickel, austenitic cast irons, known commercially as Ni-Resist, are widely used for their corrosion resistant properties. These irons are produced in several compositions and grades, depending upon the desired properties and uses of the castings.

Austenitic gray irons containing large percentages of nickel and copper are fairly resistant to sulfuric acid in all concentrations at room temperature, to hydrochloric acid, and to some concentrations of phosphoric acid at slightly elevated temperatures. These cast irons exhibit better corrosion resistance than 18-8 stainless steel in both sulfuric and hydrochloric acids under certain conditions, although they are not as good as high silicon irons. The corrosion behavior of Ni-Resist is similar to that of plain unalloyed gray iron in nitric acid. These nickel alloy cast irons exhibit fair resistance to organic acids such as acetic, oleic and stearic.

With nickel contents of 18% or higher, the irons are nearly immune to the effects of weak and strong alkalis, although subject to stress corrosion in strong hot alkalis at stresses over 10,000 psi.

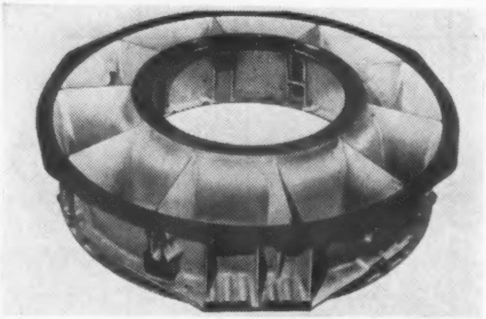
The austenitic nickel gray irons are the toughest of all cast irons containing flake graphite. Tensile strength is relatively low, ranging from 20,000 to 40,000 psi, but the advantages of satisfactory toughness, excellent machinability and good foundry properties make these irons useful in a wide range of applications in the chemical, food, automotive, marine and petroleum industries.

Alloy cast irons are used for . . .



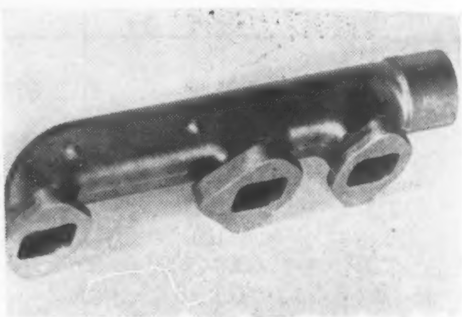
Gray Iron Founders' Society

Pump housing — *produced from high nickel-copper cast iron to withstand the corrosive action of salt solutions.*



International Nickel Co.

Center bearing support of jet engine—*consisting of high nickel ductile iron inner and outer rings connected by stainless steel struts.*



Gray Iron Founders' Society

Exhaust manifold for diesel engine—*cast of high nickel-chromium austenitic iron to withstand a combination of high temperature and corrosive gases.*

2. Heat resistant irons

The heat resisting properties of a cast iron are determined by growth and scaling characteristics and the influence of elevated temperatures on mechanical properties. Growth is a permanent increase in volume that occurs in some cast irons at elevated temperatures as the result of expansion accompanying graphitization, internal oxidation of the iron, and expansion and contraction at the critical temperature. (Gases can penetrate into the surface of hot cast iron at the graphite flakes and oxidize the graphite as well as the iron and silicon.) White irons that contain no graphite are more resistant to growth than gray irons; many white irons can be successfully used at temperatures up to 1400 F.

The high temperature characteristics of cast irons can be markedly improved by addition of various alloying elements singly and in combination. Silicon and chromium increase resistance to growth and scaling by forming an oxide film on the surface that is impervious to oxidizing atmospheres. However, both of these elements reduce toughness and thermal shock resistance. Nickel has little effect on oxidation resistance, but increases toughness and strength at elevated temperatures. Molybdenum increases high temperature strength. Aluminum helps form an adherent oxide film that reduces both growth and scaling, although room temperature mechanical properties are decreased considerably. Selection of the optimum alloy iron for elevated temperature use requires a careful consideration of service conditions, so that the properties, relative cost and availability of the various types of irons can be evaluated.

Heat resistant cast irons can be classified as follows:

1. High silicon, ferritic irons
2. High chromium, ferritic irons
3. High nickel, austenitic irons
4. High aluminum, ferritic irons

High silicon irons

Although intermediate amounts of silicon increase the rate of growth in cast iron by causing faster graphitization, additions of

Wear Resistant Irons

White or chilled cast irons suitable for applications involving severe abrasion were discussed recently in this magazine (Aug '57, pp 99-101).

4.5 to 8% silicon greatly reduce both scaling and growth. Silicon has the added advantage of raising the critical temperature to approximately 1650 F, thereby increasing the operating temperature range that can be employed without encountering a phase change. Such a high silicon cast iron is rather brittle and has low resistance to thermal shock at room temperature, but it is superior to ordinary gray iron above 500 F. An austenitic 5 silicon-18 nickel-2 to 5% chromium alloy has better toughness and thermal shock resistance.

Both of these irons are British developments; the former is known commercially as Silal and the latter as Nicrosilal. They have excellent scaling resistance in air up to 1500 F, and Nicrosilal can be successfully employed in sulfurous atmospheres. Maximum service temperatures for these irons are 1650 F for the high silicon grade and 1740 F for the silicon-nickel-chromium grade. These alloys are used in such applications as furnace grates and liners.

High chromium irons

Chromium is widely used in heat resistant irons because of its stabilizing influence on carbides, which deters growth, and its tendency to form a protective oxide film. Substantial improvement in oxidation resistance for many applications up to 1400 F is obtained by the use of only 0.5 to 1% chromium. Further improvement in resistance to scaling and growth at 1470 F, without excessive loss in toughness and machinability, is reported for cast iron containing 2% chromium. Chromium additions of 15 to 35% are employed for excellent oxidation and growth resistance at 1600 to 1800 F under atmospheric and some chemical conditions.

High chromium irons have a white structure (as discussed in the previous article on wear resistant white irons), but they can be produced with some machinability and good strength properties. Low silicon and carbon contents are desirable for toughness and thermal shock resistance. Although the thermal shock resistance of these irons is good, toughness is limited even under the best circumstances. These alloys are used for boiler parts, furnace grates, stoker links, liner plates and high temperature fittings.

High nickel irons

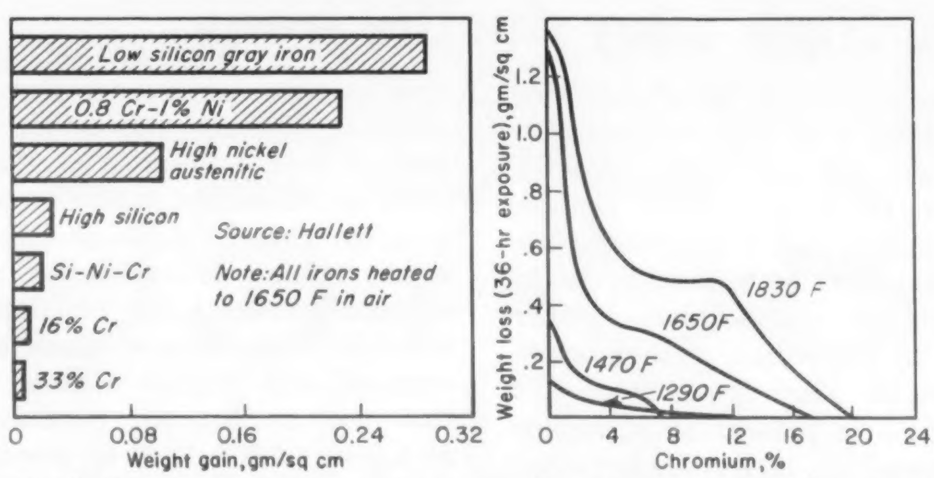
Austenitic cast irons containing 18 or more nickel, up to 7 copper, and 1.75 to 4% chromium are among the more versatile and widely used heat resistant irons. Ni-Resist is such an iron and was described previously under "Corrosion Resistant Alloy Cast Irons." Ni-Resist has good resistance to high temperature scaling and growth up to 1500 F in most oxidizing atmospheres, performs well in steam service up to 990 F, and can be used to handle sour gases and liquids up to 750 F. Maximum service temperature is 1000 F if appreciable sulfur is present in the atmosphere. A higher silicon, austenitic nickel-chromium cast iron (see table) can be used at temperatures as high as 1740 F.

Both of these irons have considerably greater toughness and thermal shock resistance than the other heat resistant alloy irons, although strength is rather low. Applications include exhaust manifolds, valve guides, turbo supercharger housings, steam lines, grates, pump casings and impellers.

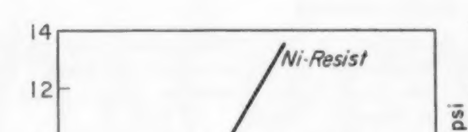
High aluminum irons

Alloy gray cast irons containing 6 to 7% aluminum; 18 to 25% aluminum; or 12 to 25 chromium-4 to 16% aluminum have considerably better resistance to scaling than several of the other alloy

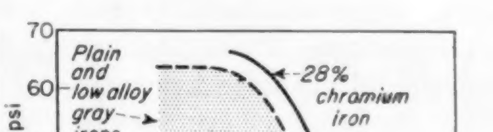
Properties of heat resistant irons



Oxidation resistance *of alloy irons depends on composition (left) and can be improved by increasing chromium content (right).*



Creep strength *of several cast irons at 1000 F* (Tapsell).



Short time tensile strength *at elevated temperatures depends on composition.*

irons, including the high silicon type. These aluminum-containing irons have been little used commercially because of brittleness and casting problems. However, they have been used for high temperature service in contact with hydrogen sulfide, sulfur dioxide and sulfur trioxide.

3. Special purpose irons

High nickel cast irons have been developed for use in equipment that requires controlled expansion or special magnetic or electrical properties.

Low expansion irons

High nickel alloy cast irons can be produced either with a low coefficient of thermal expansion for precision machines, or with a controlled high expansivity for matching other metals of different characteristics. It is possible to produce castings with thermal expansion coefficients ranging from 2.2 to 10.6 x 10^{-6} per °F by changing the alloy content of these irons. The special high nickel iron having an expansion coefficient of 2.2 x 10^{-6} per °F is used for dimensional stability in such applications as accurate machine parts, instruments, forming dies and glass molds.

Electrical resistance irons

High nickel cast irons have higher specific electrical resistances and much lower thermal coefficients of electrical resistance than gray cast iron. High aluminum cast irons also exhibit high electrical resistance. Further, austenitic irons are generally nonmagnetic, and composition can be controlled to obtain a magnetic permeability of 1.03; such castings are not attracted by an Alnico magnet. Increasing the chromium content of these irons increases the magnetic permeability somewhat, but also improves the heat and abrasion resistance. This combination of electrical and nonmagnetic properties and heat resistance results in cast irons useful for electrical resistance grids, electric furnace parts and magnetic clutch and brake parts.

4. High alloy ductile irons

The various grades of corrosion resistant, heat resistant and special purpose gray cast irons described in the foregoing sections can also be cast with the graphite in the form of spheroids, as in ductile or nodular iron, rather than in the normal flake graphite shape of gray iron. When the graphite is present as spheroids the metal has improved elastic behavior, higher elastic modulus, a definite yield point, higher tensile strength, improved ductility and impact resistance. These high alloy, spheroidal graphite irons can be efficiently used where service conditions require improved properties, although their metallurgy and production are somewhat more complex.

Among these ductile irons are: 1) a high silicon, heat resistant type; 2) an austenitic high nickel ductile iron for corrosion, erosion, frictional wear and heat resistance; and 3) another high nickel grade with high ductility and weldability. Other types of nodular graphite irons with various alloy contents are cast for specific purposes. Some representative analyses and properties of these irons are contained in the accompanying table. In the high silicon grade, scaling and oxidation resistance increases but resistance to mechanical thermal shock decreases, with higher silicon, so that most castings are purchased at 3.0 to 4.5% silicon to provide the best compromise. The austenitic ductile irons are provided with 18 to 32 nickel and 1.75 to 5.5% chromium, depending on the special properties required.

Applications of the high silicon type include furnace doors and frames, grates, sinter pots, annealing pots and glass molds. The high nickel austenitic grades are used for pump impellers and housings, exhaust lines, cylinder liners and valves.

References

Bampfyld, J. W., "Mechanical and Physical Properties of Aluminum Cast Iron," British Cast Iron Research Assn., June '52, p 340.

Burgess, C. O. and Shrubsall, A. E., "Machinable 1.5% and 2% Chromium Cast Irons to Resist Deterioration at High Temperatures," *Trans American Foundrymen's Soc.*, vol 50, 1942, p 405.

Cast Metals Handbook, American Foundrymen's Soc., 1944.

Chromium in Cast Iron, Electro Metallurgical Co., 1944.

Ductile Iron, International Nickel Co., 1956.

Engineering Properties and Applications of Ni-Resist, International Nickel Co., 1954.

Engineering Properties of Ductile Ni-Resist Austenitic Irons, International Nickel Co., 1956.

Hallett, M. H., "Modern Cast Iron," *Jnl Birmingham Metallurgical Soc.*, Mar '50, p 44.

Higgins, R. I., "The Corrosion of Cast Iron," *Jnl Reseach and Development*, British Cast Iron Research Inst., Feb '56, p 165.

Hurst, J. E., "A Review of the Developments in the Metallurgy of Cast Iron," *Metallurgia*, Nov '50, p 289.

Metals Handbook, 1948 ed., American Society for Metals.

Norbury, A. L., and Morgan, E., "Silal and Nicrosilal Heat Resisting Cast Irons," *Trans American Foundrymen's Soc.*, vol 50, 1942, p 405.

Smirnov, V. I., and Nerovetskaya, G. I., "Investigation of the Properties of Heat Resisting Cast Iron," *Metallurg*, Mar '40, p 13.

Tapsell, H. J., Becker, M. L., and Conway, C. G., "The Behavior of Five Cast Irons in Relation to Creep and Growth at Elevated Temperatures," *Jnl Iron and Steel Inst.*, vol 133, 1936, p 303.

White, W. H., and Elsea, A. R., "Growth and Scaling Characteristics of High Silicon Cast Iron," *Trans American Foundrymen's Assn.*, vol 57, 1949, p 459.

White, W. H., and Elsea, A. R., "High Silicon Cast Irons Resist High Temperatures," *Foundry*, Nov '48, p 68.

To encourage sound, imaginative and progressive use of engineering materials in the design and redesign of industrial and consumer products,

Materials in Design Engineering

announces the

1957-58 AWARDS COMPETITION

for the

Best Use of Materials in Product Design

16 AWARDS for the Best Use of Materials in Product Design

FIRST AWARD: Plaque and $500

5 AWARDS OF MERIT: Certificate and $100 each

10 CITATIONS: Certificate and $50 each

BOARD OF JUDGES

Joseph L. Bonanno
Chief Engineer,
Lionel Corp.

Raymond Loewy
Industrial Designer,
Raymond Loewy Associates

John P. Nielsen
Chairman,
Department of
Metallurgical Engineering,
New York University

Victor F. Sepavich
Manager of
Research & Development,
Crompton and Knowles Corp.

Who should enter

Any person, persons or organization in the product manufacturing industries, or consultants serving these industries, may submit an entry or entries. No one employed by a materials producer or supplier is eligible.

What should be entered

Entries may be either a new product or a redesigned product that demonstrates sound, imaginative and progressive use of engineering materials. Engineering materials are defined as metals, nonmetallics, finishes and coatings, and material forms (such as castings, forgings, moldings, etc.). The product may be a complete assembly, a subassembly, a single part or a component. Entries need not be written up in the form of an article. They will not be judged for literary quality. See back page of this folder for details on the information that must be submitted with each entry.

When to submit entries

Any product(s) whose design or redesign was completed or which went into production during the calendar year of 1957 may be entered. Entries must be mailed **no later than January 15, 1958.** Mail all entries to Awards Editor, **Materials in Design Engineering,** 430 Park Avenue, New York 22, New York.

When awards will be made

Awards will be made during the week of the Design Engineering Show, April 14-17, 1958, in Chicago. The exact time and place will be announced in an early issue of **Materials in Design Engineering.**

Publication of Entries

The award winning entries will be published in the April Design Engineering Show issue of **Materials in Design Engineering.** Other entries not winning awards may be published at the discretion of the editors. Nonwinning published entries will be paid for at the usual rate.

ENTRY FORM

ENTRY FORM

Materials in Design Engineering

1957-58 AWARDS COMPETITION

for the Best Use of Materials in Product Design

SPONSORED ANNUALLY BY MATERIALS IN DESIGN ENGINEERING • A REINHOLD PUBLICATION

IMPORTANT: OBSERVE THESE SIMPLE RULES CAREFULLY!

1. Preparation of Entries

The following information must be provided with each entry in order to allow the judges to make competent decisions.

a. A detailed description of the product including photographs or drawings. If the entry is a redesign, provide before and after illustrations if possible.

b. A description of requirements in service and/or fabrication that must be met by the product and the material.

c. A description of the previously used materials (if entry is a redesign).

d. A description of the material or materials selected for the product entry.

e. An explanation of why the material or materials were selected for the product. Describe the advantages or benefits gained through the choice. Back them up with evidence — facts, data, charts, tables on performance, quality or cost.

In general, entries should show that the materials selected for the product —

Resulted in improved performance and/or lower costs

or

Best met the design and service requirements.

Here are a few specific ways in which a product can benefit from intelligent materials selection:

Long service life	Reduced scrap
Lower basic materials cost	Reduced or eliminated maintenance
Less material required	Permitted lower cost design
Improved appearance	Allowed greater design flexibility
Permitted a new design	Simplified production and fabrication
Reduced production costs	
Improved service performance	

Remember! The more detailed and documented your entry is, the more consideration it will receive from the judges.

2. Entries or portions of entries will not be returned unless requested. Entries should not include valuable papers or other material which must be returned, because there is always some danger of loss or mutilation. Whenever possible, photostats, photographs or other copies of such materials should be used instead.

3. Materials in Design Engineering plans to publish articles on the winning entries and reserves the right to publish articles on entries not winning awards.

4. All entries must be postmarked not later than **January 15, 1958.**

NOTE: Please observe the rules given above. Use a separate blank for each entry; additional entry blanks available on request. Attach entry blank below, or its equivalent, to your entry and mail to:

Awards Editor, Materials in Design Engineering, 430 Park Ave., New York 22, N. Y.

NAME ____________________ TITLE ____________________

NAME(S) OF PERSON(S), GROUP OR ORGANIZATION WHO WOULD RECEIVE AWARD ____________________

____

COMPANY ____________________

STREET ADDRESS ____________________ CITY ____________________ STATE ____________________

NAME OR BRIEF DESCRIPTION OF PRODUCT BEING ENTERED ____________________

____

WAS DESIGN (OR REDESIGN) OF ENTRY EITHER COMPLETED OR PLACED IN PRODUCTION DURING 1957?

____

In 10 years, the potential for titanium has broadened . . .

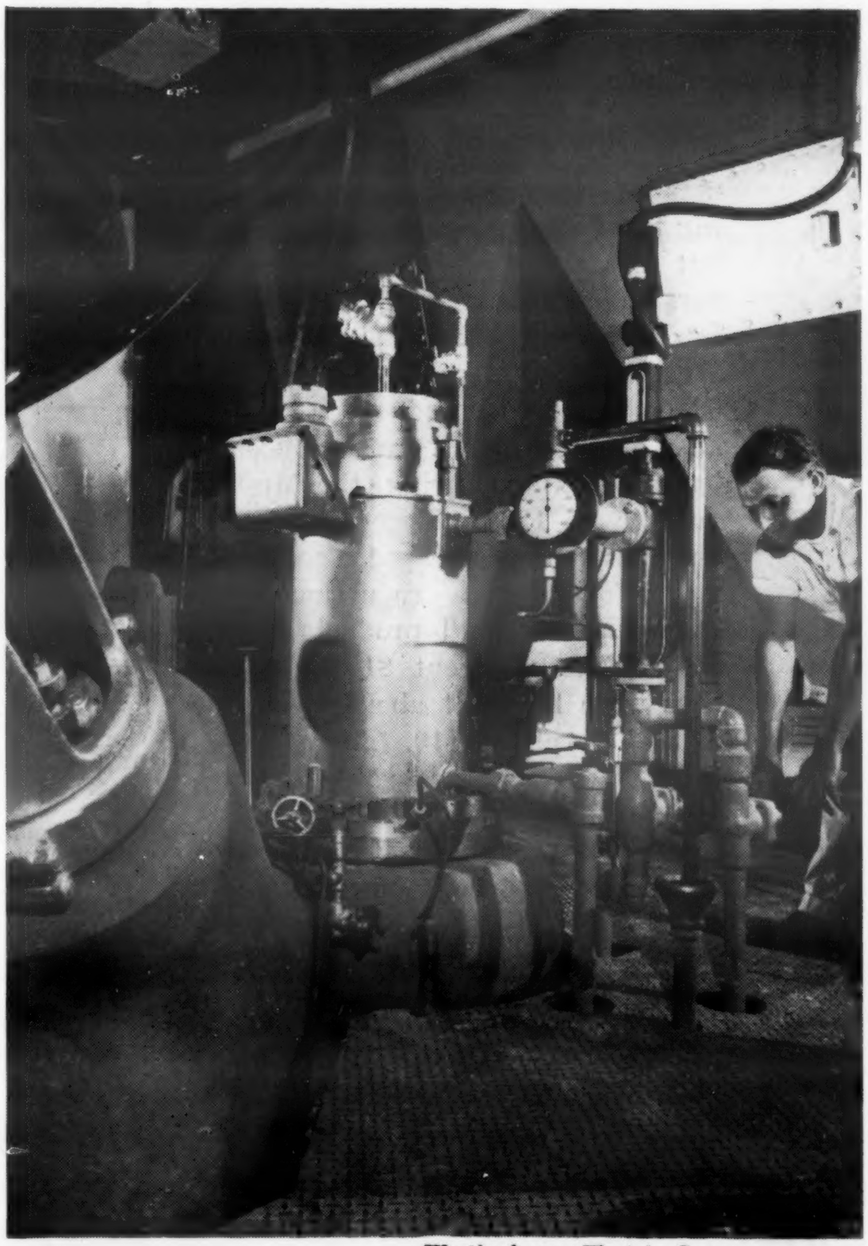
from aircraft ➡

where it offers a high strength-weight ratio . . .

McDonnell Aircraft Corp.

to process equipment ➡

where it offers unusually good corrosion resistance



Westinghouse Electric Corp.

Titanium

by John L. Everhart, *Technical Editor, Materials in Design Engineering*

*Since our first manual on titanium (*MATERIALS & METHODS, *May '52) a number of new alloys have been introduced, and a number of old alloys have been replaced. This manual covers all commercial and semicommercial alloys now in production. It provides up-to-date information on:*

- *Composition and properties*
- *Available engineering forms*
- *Working characteristics*
- *Current applications in aircraft, corrosion resistant equipment and electronics*

Materials
in Design Engineering

Manual No. 142—October 1957

Introduction

It can be considered that titanium reached commercial production in 1952 with an output of about 1000 tons of sponge. Since that time sponge production has practically doubled each year and by the end of 1956 had reached 14,000 tons. With the entry of new producers, this figure is expected to reach 20,000 to 30,000 tons by the end of 1957, although reduced demand will probably hold output near the lower figure. Accompanying these production increases have been reductions in sponge prices from $5 per lb in 1952 to $2.25 per lb in the middle of 1957.

These figures, however, apply to sponge. Production of mill products is considerably lower, reflecting not only stockpiling of sponge but also scrap losses in the conversion of sponge to forms that can be used commercially. However, the industry shipped about 5300 tons of mill products in 1956 and operated at a rate almost twice as high during the first quarter of 1957. Prices of mill products have decreased also. In July, following a reduction in sponge prices, mill products fell an average of about $1 per lb; bars were listed at about $6 per lb and sheet at $10. These are base prices and are said to be lower than corresponding prices of several vacuum melted nickel alloys now used in jet engines.

These latest reductions reflect, however, not only economies resulting from an increased scale of operations but also a reduction in demand. With the cutback in defense spending and cancellation of certain aircraft and missile schedules, defense demands for titanium were curtailed. This is a serious blow to an industry whose product is used almost exclusively in defense.

Only about 4% of the output of titanium is currently used industrially in spite of its advantages of high strength-to-density ratio and excellent corrosion resistance, particularly to oxidizing environments. This is not an unusual condition, however, since engineers must be shown the advantages of a material before they will adopt it. It takes time to prove that a material will save money, in spite of relatively high initial cost, and the results of prototype installations made several years ago are just being evaluated.

It is becoming apparent that in spite of a combination of high sponge price, wide range between sponge and mill product price, and cost of fabrication, there are civilian applications, particularly for corrosion resistance, in which titanium is truly competitive at present prices.

TABLE 1—SOME APPLICABLE SPECIFICATIONS

Type ↓	Designation			Mill Forms
	AMS	ASTM	Military	
High Purity	—	B266-52T	—	Plate, sheet, bar, billet, wire
Commercial				
40,000 Psi Min...	4902	—	—	Plate, sheet, bar, billet, wire, extrusions, tubing
55,000 Psi Min...	4900, 4900A	B265-52T, Grade 2	Mil-T-12117 (ord)	Plate, sheet, bar, billet, wire, extrusions
70,000 Psi Min...	4901, 4921	B265-52T, Grade 3	Mil-T-9047A-CL1, Mil-T-7993A-CL1, Mil-T-12117-CL70	Plate, sheet, strip, bar, billet, wire, extrusions
Alloys				
3 Al-5 Cr........	4927	—	Mil-T-9047A (ASG)	Plate, bar, billet, rod, forgings
4 Al-4 Mn.......	4925	—	Mil-T-12117 (ord)	Plate, bar, billet, forgings
5Al-1.5 Fe-1.5 Cr-1.2 Mo........	49AC	—	CL120, Mil-T-9047B (ASG)	Bar, billet, rod, wire, extrusions, forgings
5 Al-2.5 Sn......	49AE	—	Mil-T-12117 (ord), CL120, Mil-T-009046	Plate, sheet, strip, bar, billet, wire
6 Al-4 V........	49AA	—	Mil-T-12117 (ord), CL120, Mil-T-009046	Plate, sheet, bar, billet, rod, wire, extrusions
2 Fe-2 Cr-2 Mo..	4923	—	Mil-T-9047A (ASG)	Sheet, bar, forgings
8 Mn............	4908	—	Mil-T-009046	Plate, sheet, strip
3.25 Mn-2.25 Al..	—	—	Mil-T-12117 (ord), CL100	Plate, sheet, bar, billet, wire

[a]Includes iodide process crystal bar and products from newer processes such as electrolysis of fused salt baths.
Source: Titanium Metallurgical Laboratory, Battelle Memorial Inst., April 1957.

Commercial Grades and Alloys

Numerous attempts have been made to develop other methods of production but most commercial titanium is still produced by the Kroll process (reduction of titanium tetrachloride by magnesium), although reduction of the tetrachloride by sodium is gaining favor. Iodide titanium is produced on a relatively small scale but has no present commercial uses. Electrolytic methods have not been developed to the point where they are commercially significant.

In both the Kroll and sodium processes titanium is obtained in sponge form and must be consolidated to obtain a product suitable for further working. Currently arc melting processes are em-

TABLE 2—PROPRIETARY DESIGNATIONS AND COMPOSITIONS OF COMMERCIAL AND SEMICOMMERCIAL MATERIALS

Generic Designation[a]	Producer's Designation				Nominal Composition, %					
	Mallory-Sharon	Rem-Cru	Republic	TMCA	Fe	Al	Cr	Mn	Mo	Other
Commercial Titanium[b]	MST-40, MST-55, MST-70	A-40, A-55, A-70	RS-40, RS-55, RS-70	Ti-55A, Ti-65A, Ti-75A, Ti-100A	—	—	—	—	—	—
Commercial Alloys										
3 Al-5 Cr	MST-3 Al-5 Cr	—	—	—	—	3	5	—	—	—
4 Al-4 Mn	MST-4 Mn-4 Al	C-130 AM	RS-130	—	—	4	—	4	—	—
5 Al-2.75 Cr-1.25 Fe	—	—	RS-140	—	1.25	5	2.75	—	—	—
5 Al-1.5 Fe-1.5 Cr-1.2 Mo	—	—	—	Ti-155A	1.5	5	1.5	—	1.2	—
5 Al-2.5 Sn	MST-5 Al-2.5 Sn	A-110 AT	RS-110C	Ti-5 Al-2½ Sn	—	5	—	—	—	2.5 Sn
6 Al-4 V	MST-6 Al-4 V	C-120 AV	RS-120A	Ti-6 Al-4 V	0.25 max	6	—	—	—	4 V
2 Fe-2 Cr-2 Mo	—	—	—	Ti-140A	2.2	—	2.1	—	2.0	—
8 Mn	MST-8 Mn	C-110 M	RS-110A	—	—	—	—	8	—	—
3.25 Mn-2.25 Al	—	—	RS-110B	—	—	2.25	—	3.25	—	—
Semicommercial Alloys										
2.5 Al-16 V	MST-2.5 Al-16 V	—	—	—	—	2.5	—	—	—	16 V
4 Al-3 Mo-1 V	—	—	—	Ti-4 Al-3 Mo-1 V	—	4	—	—	3	1 V
6.5 Al-3 Mo-1 V	—	—	—	Ti-6.5 Al-3 Mo-1 V	—	6.5	—	—	3	1 V
6.5 Al-3.75 Mo	—	C-130 AMo	—	—	—	6.5	—	—	3.75	—
8 Al-2 Cb-1 Ta	MST-821	—	—	—	—	8	—	—	—	2 Cb, 1 Ta
8 Al-1 Mo-1 V	—	—	—	Ti-8 Al-1 Mo-1 V	—	8	—	—	1	1 V

[a]Generic designations for alloys are approximate compositions.
[b]Commercial titanium is generally specified by yield strength rather than composition. AMS specifications cover three grades having minimum yield strengths of 40,000, 55,000 and 70,000 psi, respectively.

ployed commercially to produce a suitable ingot. A combination of hot and cold working produces the desired shape after melting. Commercial titanium—the name generally given in the industry to commercially pure titanium as distinguished from the alloys—is available in plate, sheet, strip, rod, bar, forgings, tubing, pipe and pipe fittings, wire, wire cloth and special shapes. Although the metal is highly reactive with gases and mold materials at elevated temperatures—a factor which delayed the production of commercial castings—these problems have been overcome sufficiently to permit the production of various parts on a limited scale by special casting methods.

Titanium can also be obtained as a surface on other metals. Cladding by rolling can be performed by special techniques, and availability of carbon steel clad with titanium has been announced recently. Plating of titanium on other metals is still in the development stage, although several promising methods have been described recently.

Several grades of commercial titanium are currently in production, their properties varying with the purity of the material—especially with the nitrogen, oxygen and carbon content and possibly with the hydrogen content. Because of analytical difficulties, commercial grades are generally based on yield or tensile strength. For example, the Aeronautical Materials Specifications of the SAE cover three grades having minimum yield strengths of 40,000, 55,000 and 70,000 psi respectively. On the other hand, the ASTM specification covers both chemical composition and mechanical properties for four grades. Applicable specifications are given in Table 1.

Although a great many alloy compositions have been investigated in the laboratory, only a few are available commercially at present. These can be divided roughly into three groups:

1. Those developed for use as flat products, bar and forgings—including 5 Al–2.5 Sn, 6 Al–4 V, 2 Fe-2 Cr-2 Mo, 3 Mn-1.5 Al and 3.25 Mn–2.25 Al.

2. Those developed primarily for bar and forgings—including 3 Al–5 Cr, 5 Al–2.75 Cr–1.25 Fe, 5 Al–1.5 Fe–1.4 Cr–1.2 Mo, and 4 Mn–4 Al.

3. Those developed primarily for flat products—including 8 Mn and the semicommercial alloys, 6.5 Al–3.75 Mo and 2.5 Al–16 V.

In general, these alloys contain combinations of iron, aluminum, chromium, manganese, molybdenum, tin and vanadium. Elements such as iron, chromium, vanadium, molybdenum and manganese tend to stabilize the high temperature modification (the beta phase) of titanium and to produce alloys that are hardenable by heat treatment. Aluminum, tin, nitrogen and oxygen tend to strengthen the low temperature modification (the alpha phase). Some of these alloys have been established for sufficient time to be covered by various standards; and several are marketed by more than one producer, although each has his own designation for the composition (see Table 2).

British D.T.D. specifications have just been issued covering two grades of commercial titanium and a titanium-aluminum-manganese alloy.

Engineering properties of

NOMINAL PHYSICAL PROPERTIES

Type	Density, lb/cu in.	Melting Temp Range, F	Ther Cond (68 F), Btu/hr/sq ft/°F/ft	Coef of Ther Exp (68-1000 F), per °F	Spec Heat (68 F), Btu/lb/°F	Elec Res (68 F), microhm-cm	Mod of Elasticity, psi	Mod of Rigidity, psi
Commercial Titanium	0.163	3135	10-11.5	5.5×10^{-6}	0.13	49–55	$15\text{-}15.5 \times 10^6$	6.5×10^6
Commercial Alloys								
3 Al-5 Cr	0.166	3000–3045	—	5.5×10^{-6}	—	145–150	—	—
4 Al-4 Mn	0.163	2800–3000	4.0	5.4×10^{-6}	0.13	146	16×10^6	6.3×10^6
5 Al-2.75 Cr-1.25 Fe	0.163	—	—	—	—	—	16×10^6	—
5 Al-1.5 Fe-1.5 Cr-1.2 Mo	0.165	—	4.8	5.7×10^{-6}	—	162	16.5×10^6	6.3×10^6
5 Al-2.5 Sn	0.161	2820–3000	4.5	5.2×10^{-6}	0.12	157	16×10^6	—
6 Al-4 V	0.160	3020	4.2	5.2×10^{-6}	—	170	16.5×10^6	6.3×10^6
2 Fe-2 Cr-2 Mo	0.169	3000	6.8	5.0×10^{-6}	—	75	16.5×10^6	—
8 Mn	0.171	2730–2970	6.3	6.0×10^{-6}	0.12	125	16×10^6	6.0×10^6
3.25 Mn-2.25 Al	0.165	—	—	—	—	—	—	—
Semicommercial Alloys								
2.5 Al-16 V	0.168	—	—	—	—	—	16×10^6	—
8 Al-2 Cb-1 Ta	0.158	—	—	—	—	—	17×10^6	—

NOMINAL MECHANICAL PROPERTIES AT ROOM TEMPERATURE

Type	Form	Heat Treatment	Yield Strength (0.2% offset), 1000 psi	Tensile Strength, 1000 psi	Elong (2 in.), %	Red. of Area, %	Rockwell Hardness	Shear Strength, 1000 psi	Impact Strength (Charpy V-notch), ft-lb
Commercial Titanium									
40,000 Psi Min	Sheet	Annealed	50	65–70	26	50	A53	48	—
55,000 Psi Min	Sheet	Annealed	65	80–85	24	50	A59	55	—
70,000 Psi Min	Sheet	Annealed	80	90–100	20	42	A60	65	—
Commercial Alloys									
3 Al-5 Cr	Bar, 1 In.	Ann. 1 Hr, 1300 F	145	155	13[a]	35	C32	—	13
4 Al-4 Mn	Bar	Ann. 1 Hr, 1300 F	135	145	14[a]	35	C32	102	14-17
5 Al-2.75 Cr-1.25 Fe	Bar, 1 In.	Ann. 1 Hr, 1450 F	158	164	15	40	C36	—	10-15
	Bar, 1 In.	½ Hr, 1450 F, WQ; 6 Hr, 900 F	175	185	10	20	C39	—	—
5 Al-1.5 Fe-1.5 Cr-1.2 Mo	Bar, 2 In.	Mill Annealed	140	155	15[a]	35	C36	—	14
		Heat Treated	173	180	15	25	C40	—	12
5 Al-2.5 Sn	Sheet, Bar	Annealed	120	125	18	40	C30–35	73	—
6 Al-4 V	Bar, 1 In.	Ann. ½ Hr, 1500 F	130	140	13	40	C33	—	15-25
	Bar, 1 In.	½ Hr, 1750 F, WQ, 2 Hr, 1000 F	150	170	13	14	C38	—	—
	Sheet	Ann. 1 Hr, FC to 1100 F, AC	125	135	12	—	—	—	—
2 Fe-2 Cr-2 Mo	Bar	Mill Annealed	120 min	130 min	15 min[a]	25 min	C36 max	—	—
	Sheet	Mill Annealed	110–140	120 min	12 min	—	—	—	—
8 Mn	Sheet	Ann. 1 Hr, 1250 F, FC to 900 F	120	135	15	—	A60	—	—
3.25 Mn-2.25 Al	Sheet	Annealed	120	132	16	—	—	—	—
Semicommercial Alloys									
2.5 Al-16 V	Sheet	⅓ Hr, 1400 F, WQ	45	109	11	—	—	—	—
	Sheet	⅓ Hr, 1400 F, WQ; Aged 24 Hr, 900 F	146	165	4	—	—	—	—
4 Al-3 Mo-1 V	Sheet	Annealed	123	133	11	—	—	—	—
	Sheet	1650 F, WQ; Aged 12 Hr, 925 F	155	181	8.5	—	—	—	—
6.5 Al-3 Mo-1 V	Bar	Ann. 24 Hr, 1300 F	150	155	17	45	—	—	—
	Bar	1650 F, WQ; Aged 24 Hr	167	180	12	43	—	—	—
6.6 Al-3.75 Mo	Bar		152	160	—	—	—	—	—
8 Al-2 Cb-1 Ta	Bar, ⅝ In.	Ann. 1 Hr, 1650 F	123	130	16[a]	38	—	—	45
	Sheet, 0.040 In.	Ann. ⅓ Hr, 1650 F	120	127	16	—	—	—	—
8 Al-1 Mo-1 V	Bar	Ann. 24 Hr, 1400 F	132	137	18	47	—	—	—

[a]Elongation in 1 in.

PROPERTIES AT LOW TEMPERATURES

Type	Temp, F	Ten Str 1000 psi	Yld Str (0.2%), 1000 psi	Elong (2 in.), %	Red. of Area, %	Impact Str, ft-lb
Commercial Titanium[a]	Room	79	—	22	50	—
	-110	100	—	—	—	15
	-321	144	—	41	55	11
4 Al-4 Mn[b]	Room	149	143	20[e]	41	10
	-108	172	169	15[e]	26	5.7
	-321	256	254	2[e]	5	2.6
	-423	—	—	—	—	3.3
5 Al-2.5 Sn[c]	Room	133	123	16	40	—
	-100	160	136	20	32	—
2 Fe-2 Cr-2 Mo[d]	-200	218	—	20	13	—
	-321	275	—	11	4	—
8 Mn[d]	-100	160	—	13	11	—
	-200	175	—	12	10	—
	-321	220	—	6	4	—

[a]Geil and Carwile. [b]Bishop, Spretnak and Fontana. [c]Rem-Cru Titanium, Inc. [d]Ripling. [e]Elongation in 1 in.

STRESS RUPTURE PROPERTIES

Type	Stress (1000 psi) to Produce Rupture in 1000 Hr at . . .			
	400 F	600 F	800 F	1000 F
Commercial Titanium				
55,000 Psi	42	36	10	4
70,000 Psi	44	32	16	5
Titanium Alloys				
4 Al-4 Mn	110	95	46.5	—
5 Al-2.5 Sn	76	65	58	20
6 Al-4V (annealed)	—	90[a]	40[b]	20[c]
6 Al-4V (heat treated)	—	100[a]	65[b]	23[c]
8 Mn	100	91	26	—

[a]750 F. [b]850 F. [c]950 F.
Sources: Rem-Cru Titanium, Inc. and Titanium Metals Corp. of America.

Engineering Properties

Some of the physical and mechanical properties of titanium and the commercial alloys are given in the tables and graphs on pp 152 to 154. Melting point of the metal is higher than those of any of the metals currently in use as constructional materials, and density is intermediate between those of aluminum and steel. Electrical resistivities of titanium and the stainless steels are similar. Modulus of elasticity of titanium is somewhat more than half that of steels, and coefficient of expansion is less than half that of austenitic stainless steels.

Mechanical properties

Titanium is a very active metal and readily dissolves carbon, oxygen and nitrogen. All three strengthen the metal, oxygen and nitrogen having the most pronounced effects. Control of the content of these three elements is a problem in obtaining satisfactory ingots, and variations in the sponge cause considerable differences in the mechanical properties of commercial titanium.

The high melting point of titanium led to the thought that the metal would be suitable for applications at high temperatures. Unfortunately this is not the case. Both oxygen and nitrogen are ab-

CREEP PROPERTIES AT 750 F

Type	Stress, 1000 psi	Duration, hr	Creep Rate, in./in./hr
Commercial Titanium			
(70,000 psi)	20	—	1×10^{-6}
Titanium Alloys			
3 Al-5 Cr	50	300	15×10^{-6}
4 Al-4 Mn	50	300	19×10^{-6}
6 Al-4 V	50	300	7×10^{-6}
8 Mn	30	—	1×10^{-6}

Source: Mallory-Sharon Titanium Corp.

FATIGUE PROPERTIES[a]

Type	Tensile Strength, 1000 psi	Fatigue Strength 1000 psi	Endurance Ratio
Commercial Titanium	100	60	0.60
3 Al-5 Cr	155	85	0.55
4 Al-4 Mn[b]	150	90	0.60
4 Al-4 Mn[c]	174	106	0.61
5 Al-1.5 Fe-1.5 Cr-1.2 Mo	155	100	0.65
5 Al-2.75 Cr-1.25 Fe[b]	164	92	0.56
6 Al-4 V	136	69	0.55

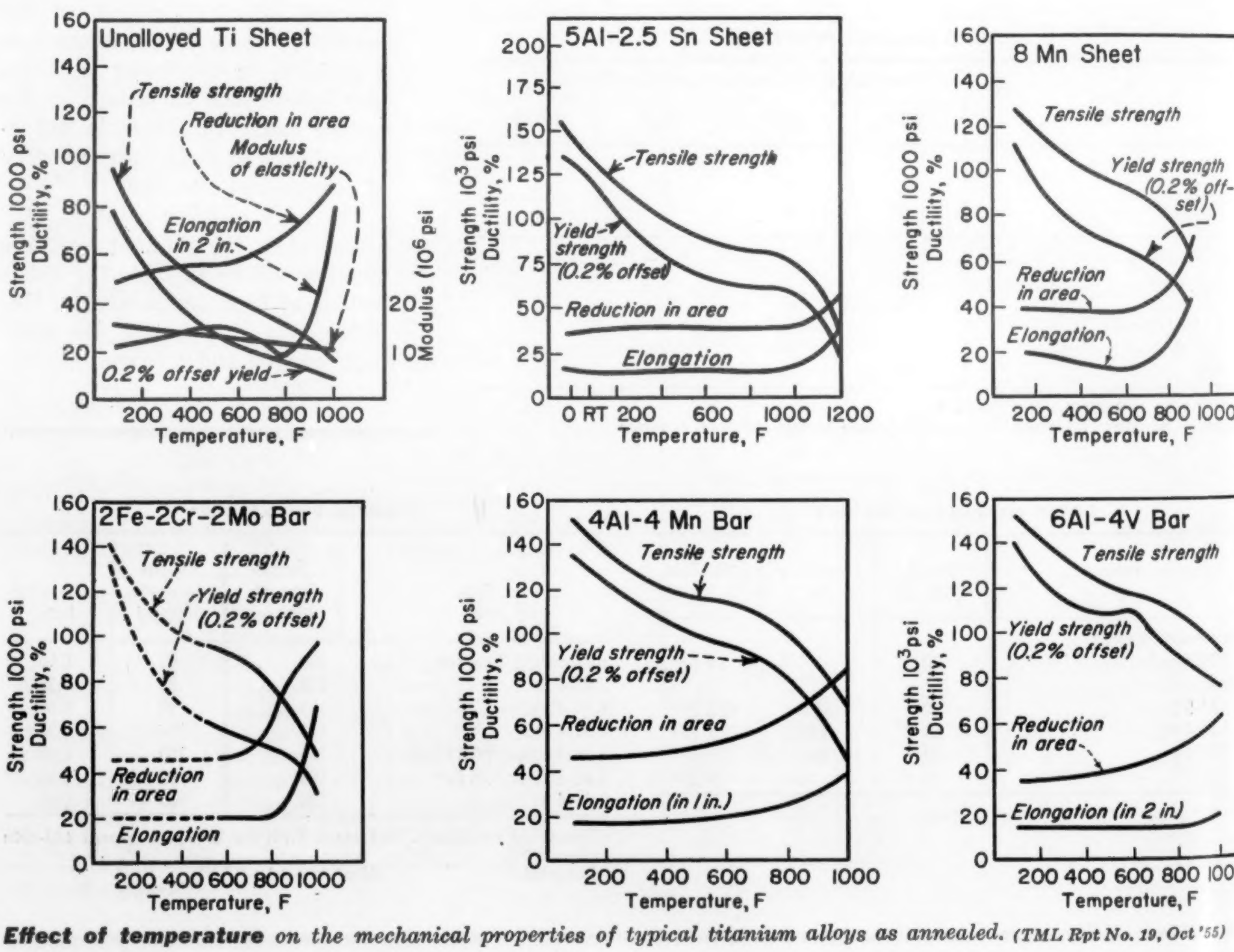
[a]Unnotched specimens. Endurance limit for 10^8 cycles except 4Al-4Mn alloy (10^7).
[b]Annealed. [c]Heat treated.

sorbed by titanium at high temperatures. Below 1100 F a protective oxide film is formed on unalloyed titanium and the oxidation rate decreases with time; above 1100 F a protective scale is not formed and penetration of oxygen occurs at rates that are sufficient to shorten significantly the useful life of a component and to cause fabricating problems. Present commercial alloys scale at rates that are at least equal to, and may be greater than, those for the unalloyed metal. It does not appear that titanium alloys will be useful for continuous service at temperatures above 1000 F unless some means of protecting the surface from oxidation is devised. At present some producers consider 800 F as the upper limit for continuous service and 2000 F the limit for intermittent service.

In general, commercial titanium is reasonably ductile and insensitive to notches, although some loss in ductility is apparent at low temperatures with severe notches (such as the V notch used in the Charpy test). The alpha alloys, such as 5 Al-2.5 Sn, are more sensitive to notches than commercially pure material. The alpha-beta alloys in the annealed condition are not notch sensitive at room temperature, but show increasing tendencies toward transitional behavior (as occurs in carbon steels) as the beta phase increases. These alpha-beta alloys become increasingly notch sensitive when heat treated to strength levels above 150,000 psi.

Certain impurities affect notch sensitivity. Carbon, oxygen and nitrogen are detrimental to some degree, but the element most responsible for embrittlement is hydrogen. This embrittlement becomes particularly severe in the presence of a notch at temperatures below 200 F, and the most sensitive method of detecting degree of embrittlement of titanium and its alloys is a notch impact test. In this test hydrogen causes loss of toughness in unalloyed titanium when present in quantities as low as 200 parts per million. In alloys, the hydrogen tolerance depends on the composition. Having recognized the problem, the producers have devised effective controls to keep the hydrogen level in commercial titanium products at a level sufficiently low to minimize embrittlement resulting from hydrogen absorbed during melting. Hydrogen picked up by the solid metal during acid pickling can be removed by vacuum annealing.

The fatigue strengths of titanium and its commercial alloys compare favorably with those of steels when the determination is made on standard polished specimens. As a matter of fact, the ratios of fatigue strength to tensile



Effect of temperature *on the mechanical properties of typical titanium alloys as annealed.* (TML Rpt No. 19, Oct '55)

strength for some of the titanium alloys are higher than steels.

Titanium and its alloys appear to have excellent properties for applications involving cyclic stresses in corrosive environments. Endurance tests made in air and sea water indicate, if anything, that fatigue strength in sea water is higher than in air.

Corrosion resistance

The most outstanding corrosion attribute of titanium is its resistance to salt solutions; with the exception of aluminum chloride and high concentrations of zinc chloride, unstressed titanium seems to be completely resistant to corrosion by salts. Salts such as ferric chloride have even inhibited attack by various mineral acids. The metal is particularly resistant to attack by sea water and is not pitted by stagnation in crevices, under moist salt crystals, or under fouling growths.

Titanium is resistant to oxidizing acids such as nitric, chromic and aqua regia, to dilute hydrochloric and to most organic acids at room temperature. It is attacked by concentrations over 4% of hydrochloric acid, the rate increasing with the temperature. The metal is not resistant to hydrofluoric, sulfuric, oxalic and formic acids. These acids also produce crevice corrosion of titanium under some conditions, although the metal has good resistance to crevice corrosion in most media.

Titanium is resistant to dilute alkalis but is attacked by moderately concentrated solutions. No information is available on the susceptibility of titanium to caustic embrittlement.

Solution potential studies show that titanium is cathodic to most of the metals used in aircraft construction. Service experience has shown that corrosion rates of magnesium, aluminum and carbon and low alloy steels can be more than doubled when coupled with titanium in sea water. Stainless steel resists galvanic corrosion when coupled with titanium. As used in aircraft, titanium accelerates the corrosion of aluminum or magnesium to which it is coupled, the effect being similar to that obtained when stainless steel is coupled to these metals.

Considerable service testing has been carried out in the chemical and process industries, particularly for handling corrosive chloride solutions, and results have indicated a definite field of application for the metal even at its present prices. However, there are so many factors affecting corrosion rates that tests should be made under service conditions before the metal is selected for applications involving corrosion.

Fabricated Forms

Titanium and its alloys can be fabricated by sheet metal forming methods, by forging and, to a limited extent, by casting. With increasing knowledge of the properties many of the early difficulties have been overcome.

Sheet metal parts

Uniformity of properties of sheet material has improved greatly, but fabricators still say that nonuniformity is one of the major problems in handling titanium. Apparenty there is still too much variation in directional properties, sheet thickness and flatness, all of which are important in forming sheet. High yield strengths are also blamed for fabricating difficulties. For example, difficulty was reported in forming certain shapes from 8 Mn sheet having a yield strength of 130,000 psi, although the same shapes could be formed readily from 8 Mn sheet having a yield strength of 113,000 psi.

One important problem in the forming of titanium sheet is that, whereas the limit of uniform elongation of commercial titanium alloys is about 7% for annealed material and 8 to 12% for solution treated materials, metal forming machinery and processes were developed for materials having uniform elongation values greater than 12%. Considerable work is required to adapt available equipment to the forming of titanium.

Bending, the most common forming operation, includes all procedures in which the material is forced over a straight edge. Titanium and its alloys can be bent in the power brake using methods developed for stainless steel. Springback at room temperature can be compared with that encountered in bending cold worked stainless; generally, titanium springback is two to three times as great as that of hard stainless steel. Hot forming is necessary for tight bends or small bend radii; temperatures in the range 500 to 600 F are satisfactory for titanium and its alloys.

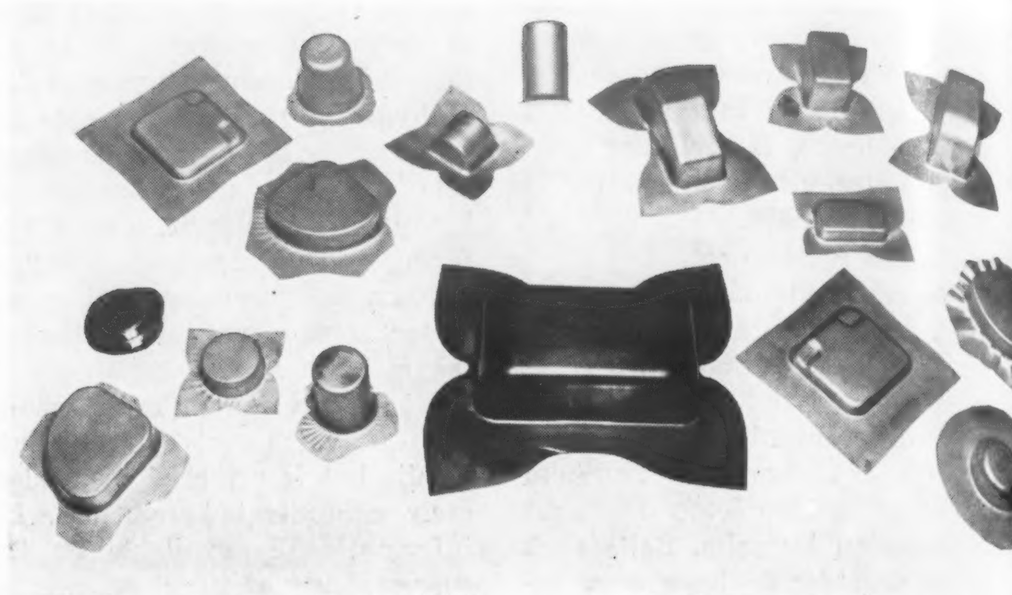
Annealed commercial titanium sheet up to 0.095 in. thick can take a cold bend of 180 deg on a radius of ½T when bent parallel to the rolling direction, and on a radius of ¾T when bent perpendicular to the rolling direction. In the aircraft industry, bends of 3 to 5T have been used to compensate for property variations in sheet.

Bending of half hard sheet requires radii on the order of 5T. Several aircraft organizations double this figure for room temperature bending, but reduce the radius to 5T by heating the material to 500 to 600 F.

Blanking commercially pure titanium sheet on a punch press is similar to blanking 18-8 stainless steel in the ¼ hard condition, whereas the alloys may be compared with ½ hard 18-8. The force required for titanium and its alloys is greater and the die life shorter, however. Holes, slots and flat patterns can be blanked about as easily as in stainless.

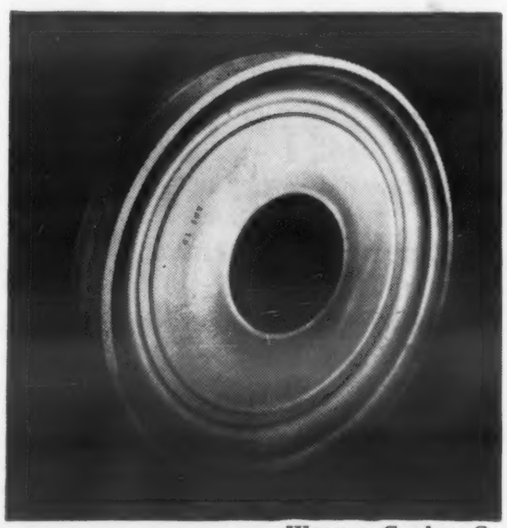
Hammer forming gives best re-

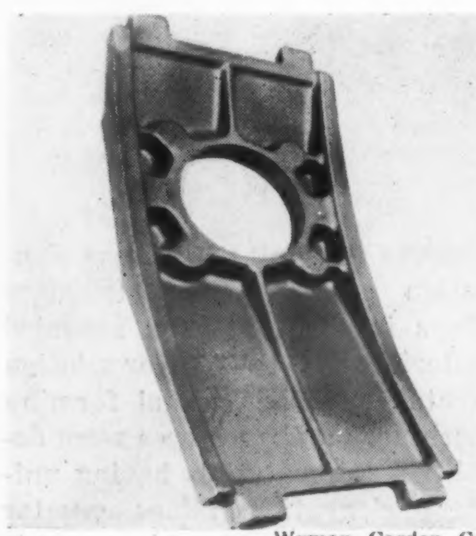
Titanium can be used

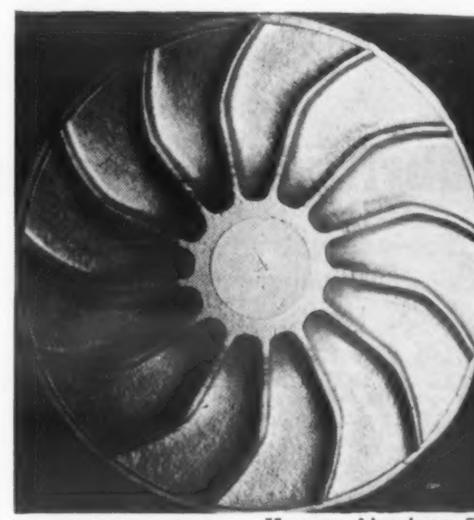


Brooks & Perkins, Inc. | Worcester Pressed Steel Co.

Drawn parts. *Parts at left are hot drawn in one operation from commercial titanium and 8 Mn alloy titanium. Titanium can be hot drawn with the same tooling used in drawing magnesium. Parts at right are cold drawn from commercial titanium. Although stress relieving is required after cold working, this method of fabricating is more familiar to most press shops than hot drawing and therefore may be preferred.*







Wyman Gordon Co. | Wyman Gordon Co. | Harvey Aluminum Div.

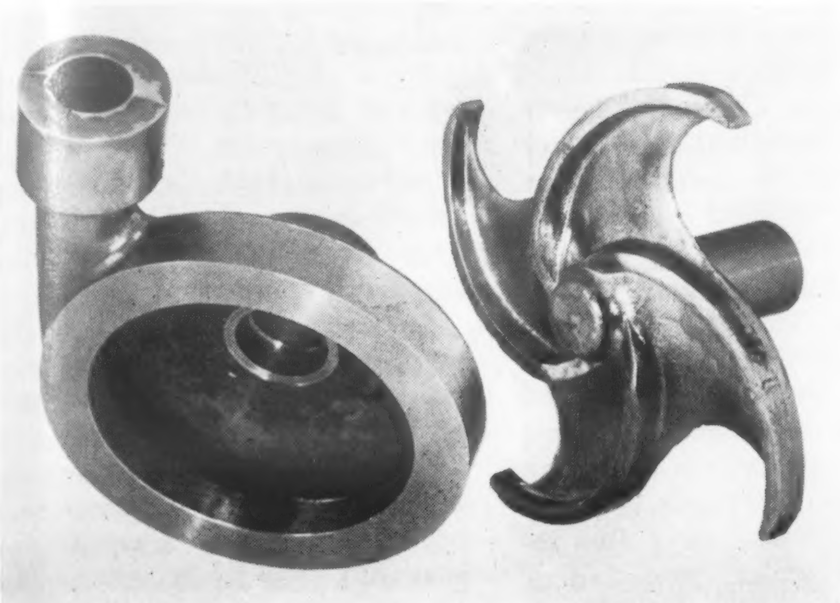
Forged parts. **Left**—*Compressor disk for jet engine forged from 6 Al-4 V. This disk is 20.2 in. in dia.* **Middle**—*Mount pad for jet engine.* **Right**—*Impeller part press forged from 6 Al-4 V. Close tolerances obtained with this no-draft design eliminated major machining.*

sults with materials ranging in thickness from 0.032 to 0.051 in. The limits in working titanium and its alloys are about 6% for cold working and 10% for hot working. Difficult shapes can be hot formed successfully using conventional die materials. Dies should be heated to about 400 F, and the stock to 800-900 F for commercial titanium or 1100-1250 F for the alloys.

Rubber forming is used widely in airframe construction for forming simple flat or slightly curved parts having stretched flanges. Depending on the severity of the operation, forming may be done at room temperature or at temperatures in the range 675 to 750 F. Springback following room temperature forming compares with that encountered in forming ¼ or ½ hard stainless steels. Die materials normally used for stainless steel or aluminum are suitable for forming titanium.

Stretch forming of titanium and its alloys is one of the most successful forming operations. Cold stretching at slow uniform rates with a maximum extension of about 13% is generally satisfactory for commercially pure material and the 8 Mn alloy. Springback of commercial titanium has

in many different forms



Oregon Metallurgical Corp.

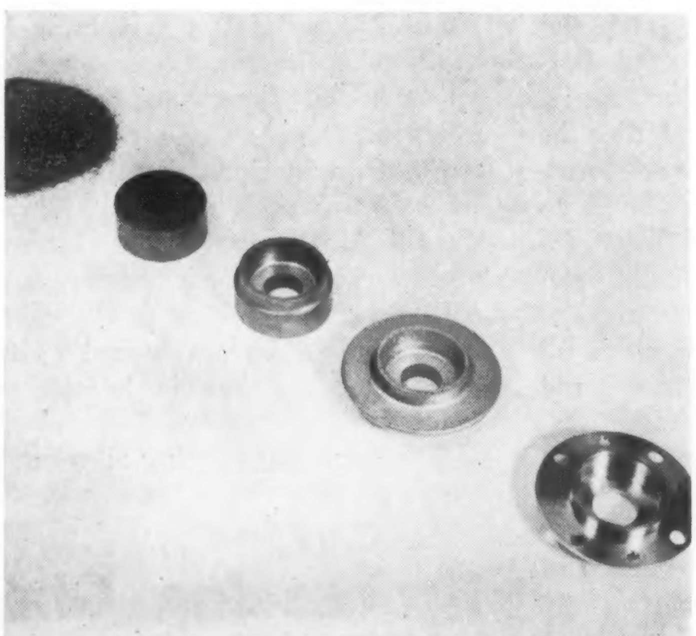
Castings. *Impellers and pump casings cast from titanium by special techniques have strength equivalent to that of wrought materials but somewhat lower ductility.*

Johnston & Funk Titanium Corp.

Weldments. *Inlet guides and front compressor cases for a jet engine are welded in a transparent plastic chamber by the inert gas metal arc process using an argon atmosphere to avoid contamination of titanium by the air.*

I-T-E Circuit Breaker Co.

Spun parts. *This part was hot spun readily from titanium sheet.*



General Electric Co.

Metal powder parts. *This photo shows five steps in the production of a bearing housing for a jet engine. Properties of this part were equal to those obtained in wrought material.*

been compared with that of half hard stainless steel; in general, the alloys have greater springback.

Spinning of titanium and certain titanium alloys has been done at elevated temperatures in the range of 1000 to 1200 F using conventional methods. Recently a pressure vessel head has been spun successfully from ¼-in. plate with no unusual springback occurring.

Drawing of commercial titanium can be done cold or hot, depending on the severity of the operation, but most parts are formed at 500 to 600 F; alloy parts are generally drawn at 900 to 1100 F. Lubrication is essential in cold drawing, and desirable in elevated temperature drawing, to reduce cracking tendencies. Chemical conversion coatings combined with high pressure lubricants have shown promise in reducing seizing and galling during drawing. Press speeds should be lower than those used for steel, and more frequent annealing is required (if parts are drawn cold).

Dimpling of sheet for flush-head rivets requires high pressure. With some rivet sizes the opration can be accomplished successfully at room temperature. For large diameter rivets or for work hard-

ened material it is necessary to heat the sheet before dimpling to prevent cracking. Temperatures in the range of 500 to 600 F are satisfactory.

Formed tubing

Commercial titanium tubing has excellent ductility and can be flattened and flared at room temperature. Room temperature flare tests indicate that the inside diameter can be expanded a minimum of 22%, and as high as 70% in thin walled tubes. Bending, spinning and similar operations are more sucessful if the tube is heated to 500-600 F.

Forgings

Forging of titanium and its alloys has reached the production state of the art, it is difficult to fill tion on procedures is available. In flow characteristics titanium is closer to aluminum than it is to steel. Titanium alloys are comparable with 7075 aluminum in forging characteristics and the same equipment can be used. Differences in shrinkage characteristics require that special dies be used. Because of rapid work hardening it is extremely difficult to forge thin titanium sections unless the dies are specially designed. Further, at the present state of the art it is difficult to fill die contours, and large radii and fillets are required. Intricate forgings generally require more stages than are required to produce the same part from steel.

Some organizations recommend that the upper temperature limit for forging be 1800 F, because the rate of penetration of oxygen and nitrogen into the metal becomes very rapid at higher temperatures and the resulting scaling and surface hardening can become a serious problem. Others prefer to set the upper limit at 1700 F. Forging of most alloys should be continued until the temperature drops to 1300-1400 F if the equipment is sufficiently rugged, as the mechanical properties of the part are improved by this procedure. Reductions should be light to prevent cracking, and the initial breakdown can probably be done profitably in a press rather than under the hammer, although the die life factor must be considered in such a procedure. (This suggestion is based on the fact that titanium resists rapid deformation to a greater degree than slow deformation.) After forging, the parts should be stress relieved at 1100-1300 F as soon as possible.

Regular heating furnaces can be used, but the floor should be free from iron scale or the titanium should rest on clean bricks. It has been reported in several instances that titanium bars have reacted with mill scale, the reaction being exothermic and resulting in complete oxidation of the bar.

To reduce scale formation, the preferred practice is to soak the piece at 1200-1300 F and raise the temperature rapidly to 1700-1800 F, holding at the latter temperature for the minimum possible time. No special atmosphere is required, although excessive water vapor in the atmosphere should be avoided.

Small reductions can be made by cold swaging, but care is required in this operation. Excessive working at room temperature can result in cracking of the part. Swaging can be performed quite readily if the bar is heated to 400-500 F.

The principal forging alloys are 4 Al-4 Mn, 6 Al-4 V and 2 Fe-2 Cr-2 Mo. Commercial titanium is also supplied in forged parts.

Castings

Since liquid titanium reacts with all elements except the inert gases, production of cast parts is a problem that is just being solved. However, castings are now available on a limited scale from several organizations.

In producing the castings, the mold and furnace must be contained in a closed unit in which an inert gas atmosphere or a vacuum is maintained. Consumable electrode arc furnaces have been used, the molten metal being cast into graphite or water cooled copper molds. The limited information available indicates that these castings have strengths equivalent to those of wrought alloys of similar composition, although ductilities are somewhat lower.

Metal powder parts

Hot pressing techniques have been employed in the production of parts on a semicommercial basis. Preforms were made by hot pressing titanium powder at 1925 F in a vacuum chamber to maximum density. The preforms were then coated with a lubricant and press formed in tool steel dies at 1000 F. The parts had properties equivalent to those of wrought material.

Processing Characteristics

Machining

The type of chip formed in machining titanium alloys resembles that formed by stainless steels, but there is considerable disagreement as to the relative machinability of these materials. It has been said that commercial titanium is more difficult to machine than aluminum alloys and resembles the higher density stainless steels. On the other hand, some of the alloys compare in machinability with the jet engine disk alloys rather than with the stainless steels. Power requirements are about the same as for 18-8 stainless steels.

Colwell and Truckenmiller have pointed out that titanium has some rather unique machining properties including: 1) more superficial work hardening than occurs in other metals, 2) little tendency to form a built-up edge, and 3) formation of chips that are thin relative to the thickness of the cut, resulting in an increased problem of chip flow velocity. The relatively low cutting speeds required for optimum machining of titanium alloys tend to confirm the probability that they develop higher cutting tem-

peratures than common metals.

Comparing the machining characteristics of SAE 1020 with those of 2.7 Cr-1.3 Fe titanium alloy, *Merchant* showed that there is a big difference in the contact area between tool and chip, the contact area on the titanium alloy being only about half that on the steel. The smaller contact area pressure; in addition, the frictional heat resulting from sliding the chip over the tool is concentrated in a smaller area. These factors, combined with titanium's higher chip flow velocity and poor heat conductivity, lead to high tool temperatures. A comparison of tool temperatures under similar cutting conditions showed 600 F on the bearing area during the cutting of SAE 1020 and about 2200 F for the titanium alloy.

Temperatures in this range introduce another factor. Since practically all known metals and refractories are soluble in titanium, actual welding occurs as the titanium chip passes over the tool at a high temperature. Fragments of the tool are carried off with the chip and excessive tool wear may result. If the tool is stopped with the chip in contact with the tooth, the chip freezes to the tool as the temperature drops, leaving a layer that is the beginning of a built-up edge. This effect can be prevented by keeping the chip from cooling in contact with the tool. Difficulties in milling are directly connected with this mechanism. Chips tend to stick to the milling cutter face and upon next contact with the work are knocked off, taking particles of the tool with them.

Titanium and its alloys can be machined successfully on conventional machine tools if certain precautions are taken. Rigidity of workpiece and cutting tool are essential in all operations. In general, cutting speeds should be low and feeds should be as coarse as possible, consistent with the finish required. A good surface finish can frequently be obtained with very coarse feeds if suitably shaped tools are employed. Since titanium has a tendency to gall

TABLE 3—SUGGESTIONS FOR MACHINING[a]

Operation ↓	Surface Speed, ft/min	Feed, in./rev	Tool Angle, deg	Depth of Cut, in.
Rough Turning	Comm pure 40–50; alloys 20–30	0.004–0.008	Relief . . . 5 Edge cutting . . . 5 Rake . . . 0–5 Side cutting . . . 6	0.10+
Finish Turning	Comm pure 75–100; alloys 45–60	0.002–0.004	Relief . . . 5 Edge cutting . . . 5 Rake . . . 0–5 Side cutting . . . 6	<0.030
Face Milling	Comm pure 80–110; alloys 40–70	0.003–0.006	Radial . . . 0 Axial . . . 0 Face cutting . . . 6 Face relief . . . 12 Peripheral cutting . . . 30 Peripheral relief . . . 12 Chamfer . . . 0–45	0.05
Drilling (general)	Comm pure 60–80	0.005–0.008[b]; 0.002–0.005[c]	Included . . . 90[b], 140[c] Helix . . . 25–35 Relief . . . 9–15	—
	Alloys 20–40	0.005–0.008[b]; 0.002–0.005[c]	Included . . . 90[b], 140[c] Helix . . . 25–35 Relief . . . 9–15	—

[a]High speed steel tools (cobalt types) preferred.
[b]Drill dia: ¼ in. or larger.
[c]Drill dia: ¾ in.
Source: Titanium Metallurgical Laboratory, Battelle Memorial Inst.

and seize on other metals, sliding contact must be avoided; the tool must not be permitted to ride on the work. For high speed cutting, a cutting fluid that emphasizes cooling rather than lubrication should be used. At low speeds, sulfo-chlorinated oils are satisfactory. Brief comments on some operations are given below (see also Table 3).

Turning of titanium and its alloys is not difficult, although relatively low cutting speeds are required. Heavy cuts are required, and the tool must be continuously in contact with the work for good tool life at reasonable cost. Cobalt high speed steel tools, having tool angles indicated in Table 3, have been satisfactory. Using water soluble cutting fluids, heavy feeds and rigid machines, cutting speeds with cobalt high speed steel tools can be about 20-50 sfm for rough turning and up to 100 sfm for finish turning, depending on the alloy being cut. Carbide tools can also be used in turning. With the proper tool geometry, speeds of 150 to 300 sfm are satisfactory in turning titanium alloys with carbide tools; a cast iron grade of tungsten carbide is recommended.

Milling is more difficult than turning because of the nature of the operation. The cutter mills during part of each revolution and the chip remains welded to the tooth during the remainder. As the tooth enters the cut during the following cycle, the chip is knocked off together with a bit of the tool. This tool attrition is the major problem in milling. It can be reduced by climb milling wherever this is possible.

High speed steels, carbides or cast alloys can be used as milling cutters. High speed steel tools are generally more suitable for form cutters than the other materials. Carbide cutters, although they can be used at higher speeds and with heavier feeds, should be used for straight face milling only, preferably with climb milling techniques. Recommended feeds for milling titanium range from 0.003 to 0.006 in. per tooth.

Speeds for milling titanium alloys range from 50-70 sfm using high speed steel tools to 80-120 sfm using carbide tools. Water soluble coolants are required with steel tools but carbide tools should be used dry.

Drilling titanium requires low speeds and heavy positive feeds. The unsupported portion of the drill should be as short as possible to provide maximum torsional rigidity and minimize drill runout. To prevent galling and seizing the tool must not be permitted to ride on the work. No pilot holes should be used. Tools are preferably cobalt grades of high speed steel. Suggested tool angles are given in Table 9, but angles of 90, 118 and 140 deg should be tried on each set-up to decide which gives the best results. After the proper angle is selected it should be maintained by frequent sharpening and checking. For drill diameters less than 1/4 in. sulfurized and chlorinated coolants can be used; for larger drills mixtures of medium grade mineral oil, soluble oil and water have been satisfactory.

Tapping requires a rigid set-up. This requirement makes it necessary to use power, rather than hand, tapping. A hole to be tapped should be drilled with a sharp drill to prevent the excessive hardening of the material that can occur when a dull drill is used. Tapping difficulties can be minimized by reducing the thread to 55 or 65% from the standard 78%, by tapping the smallest number of threads permitted by the design and by using a paste type cutting compound. A three-fluted spiral point, interrupted thread tap is recommended for best results. Cutting fluids are important and sulfurized-chlorinated oils are recommended. Although unalloyed titanium bolts have been threaded with standard tangential chasers, thread rolling is preferred.

Reaming can be done successfully, but carbide tipped reamers are more satisfactory than high speed steel. Spiral fluted reamers

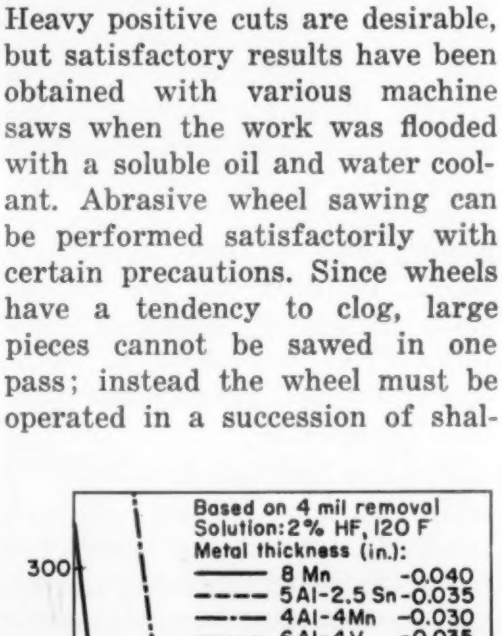
TABLE 4—SOME DESCALING PROCEDURES

Type of Scale ➜	Light Scale	Heavy Scale Formed Below 1300 F	Heavy Scale Formed Above 1300 F
1	Dip in 15% sulfuric acid for 10-15 min at room temp	Immerse in Virgo salts at 800 F for 5-20 min or in electrolytic Kolene No. 4 bath at 825-900 F for 5-10 min	Immerse in Virgo salts at 925 F for 20-30 min, or immerse in electrolytic Kolene No. 4 bath at 900-950 F for 10-20 min
2	Water rinse	Quench-rinse in water	Quench-rinse in water
3	Dip in 3 nitric-1 hydrofluoric acid at 140-160 F for 1-3 min	For commercially pure titanium, dip in 10 nitric-2 hydrofluoric-5 water at 140-160 F for 1-2 min, or dip in conc hydrofluoric acid for 10-15 sec	Dip in 10 nitric-2 hydrofluoric-3 water at 140-160 F for 2-3 min, or dip in conc hydrofluoric acid for 30-60 sec
4	Water rinse	Water rinse	Water rinse

Source: *Durkin.*

are desirable, but no single set of cutting conditions satisfies all requirements. A coolant is required and sulfo-chlorinated mineral oil gives the best performance.

Sawing is a difficult operation, particularly in large sections. Heavy positive cuts are desirable, but satisfactory results have been obtained with various machine saws when the work was flooded with a soluble oil and water coolant. Abrasive wheel sawing can be performed satisfactorily with certain precautions. Since wheels have a tendency to clog, large pieces cannot be sawed in one pass; instead the wheel must be operated in a succession of shallow overlapping cuts, keeping the area of wheel contact small and flooding the work with coolant.



Effect of nitric acid *concentration on the absorption of hydrogen during pickling.* *(Rem-Cru Titanium, Inc.)*

Grinding

Grinding and machining are closely related operations and the same basic problems are encountered, including the low thermal conductivity of titanium, solubility of the abrasive in titanium at high temperatures, and high chip flow velocity. The combination of high velocity and low conductivity leads to high temperatures, with the result that abrasive is dissolved.

Grinding of titanium is quite different from grinding of steel in the type of wheel wear resulting. With steel the greater part of wheel wear is caused by breakage; with titanium most of the wear results from attrition, probably as the result of actual solution of the abrasive in the titanium. The grinding ratio can be improved by reducing wheel speed and by using a suitable coolant, but ratios of 5 to 25 are considered normal for titanium alloys.

Aluminum oxide wheels and soft-bonded silicon carbide wheels are preferred for grinding titanium. Since titanium dust, like that of other light metals, is explosive, wet grinding should be employed. Aluminum oxide wheels are effective at wheel speeds of 1500 to 2000 sfm. Silicon carbide wheels

TABLE 5—SUGGESTED HEAT TREATMENTS[a]

Type	Annealing		Stress Relieving		Hardening			
					Solution		Aging	
	Temp, F	Time, hr	Temp, F	Time, hr	Temp, F	Time, hr	Temp, F	Time, hr
Alpha								
Commercial Titanium	1100–1350	[e]	1000	½	—	—	—	—
5 Al-2.5 Sn	1500–1600	½	1000–1200	1–2	—	—	—	—
Martensitic								
3 Al-5 Cr	1300	1	1300	½	—	—	—	—
4 Al-4 Mn	1300[b]	1	1100	1	—	—	—	—
5 Al-2.75 Cr-1.25 Fe	1450[b]	1	1200	½	1450	2[c]	1000–1100	4–24
6 Al-4 V	1450–1500[b]	½–2	1150	½	1400	½[c]	900–1100	2–8
5 Al-1.5 Fe-1.5 Cr-1 Mo	1200	24	—	—	—	—	—	—
2 Fe-2 Cr-2 Mo	1200	24	—	—	—	—	—	—
3 Mn-1.5 Al	1350[b]	⅓	—	—	—	—	—	—
Metastable Beta								
8 Mn	1200–1300[d]	1	1000–1100	⅓	—	—	—	—

Note: Air cooling is satisfactory unless otherwise noted.
[b]Slow cooling to 1000 F is advisable.
[c]Water quenching.
[d]Furnace cooling to 1000 F necessary to avoid embrittlement.
[a]Time depends on thickness and varies from ¼ to 1 hr.

should be operated at higher speeds; depending on the grade of wheel and the grinding fluid used, these speeds can vary from 2250 to 6000 sfm but, to minimize residual stresses in the ground surface, should not exceed 3000 sfm.

Cleaning

The descaling and cleaning of titanium and its alloys can be accomplished by chemical or mechanical means. Light discoloration can be removed by immersion of the part in a pickling solution composed of 2% hydrofluoric and 10% nitric acid by volume. However, this solution will not remove the scale formed when titanium is annealed in air unless the scale was formed below 1000 F.

Ease of removal of scale formed during heating titanium depends on the temperature of formation. Scale formed below 1300 F is soluble in concentrated sulfuric acid. With increasing temperatures the scale becomes more refractory, and more drastic methods of removal are required.

The most effective method of removing tough scale is descaling in solutions such as the Virgo, Kolene No. 4 electrolytic or sodium hydride baths. There is some difference of opinion as to the possibilities of embrittlement, however. Treatments shown in Table 4 are claimed to cause neither embrittlement nor excessive metal loss.

An alternate procedure is removal of the heavy scale by sandblasting or other mechanical means and completing the treatment by pickling in a nitric acid-hydrofluoric acid bath. These baths have caused embrittlement, resulting from hydrogen pick-up in some alloys. Recently it has been reported that the amount of hydrogen picked up in this type of acid pickling depends not only on the bath but also on the composition of the alloy. The variation in hydrogen pick-up with concentration and alloy composition, as shown in the accompanying graph, indicates that alpha-beta alloys (such as 6 Al-4 V and 8 Mn) are more susceptible to hydrogen contamination at low nitric acid concentrations than are alpha alloys (such as 5 Al-2.5 Sn). On the basis of this work, it has also been suggested that the nitric acid content of baths used to pickle alpha-beta alloys be maintained at about 20%.

Finishing

Electroplating on titanium to produce wear resisting surfaces has been commercialized with the introduction of hard chromium plating. Copper plating to reduce galling during working has been practiced for a number of years, and nickel plating is also successful, although heat treatment is required to obtain an adherent coating. Titanium can be coated by dipping and by spraying (procedures that have been used successfully in applying aluminum to titanium) and by chemical replacement, a method used to coat titanium with nickel.

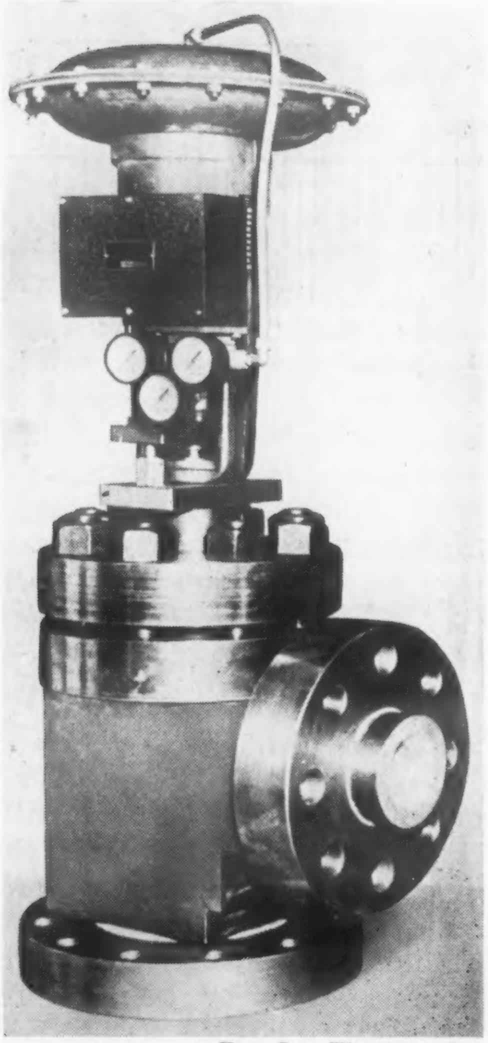
Titanium can be anodized by treatment in a chromic or sulfuric acid bath. The surface resulting from this treatment can be dyed and sealed by procedures similar to those used for aluminum.

Titanium can also be painted satisfactorily after suitable surface preparation. Bases for paints can be obtained by applying a zinc chromate primer after anodizing or by using a priming coat of metal conditioner. Fluoride-phosphate immersion coatings are also useful in obtaining improved paint adherence on titanium.

Heat treatment

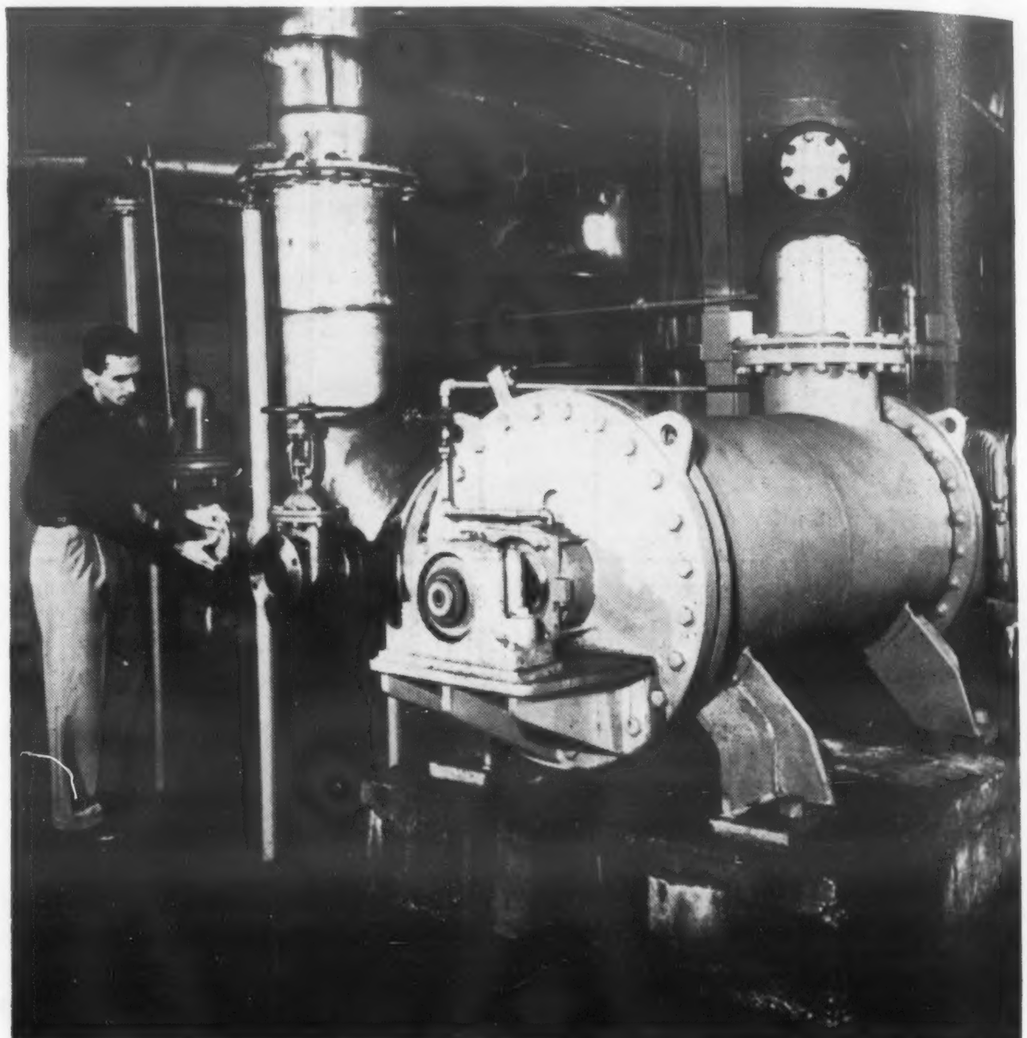
Through hardening—The crystal structure of titanium changes at 1625 F from hexagonal close packed alpha (stable from room temperature to 1625 F) to body centered beta (stable above 1625 F). Slight hardening effects resulting from this structural change have been reported for quenched titanium but have no practial significance. On the other

Excellent corrosion resistance makes titanium



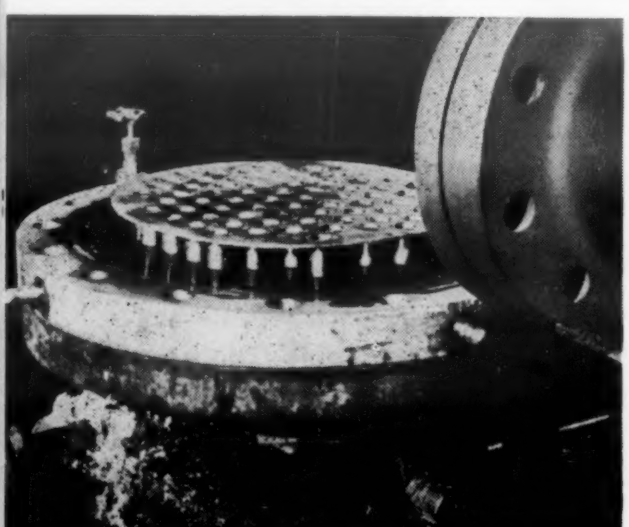
Rem-Cru Titanium, Inc.

Valve *forged from commercial titanium handled a corrosive and erosive fluid at high pressure for 1680 hr without being overhauled. A stainless steel valve used previously required overhauling after 70 hr service.*



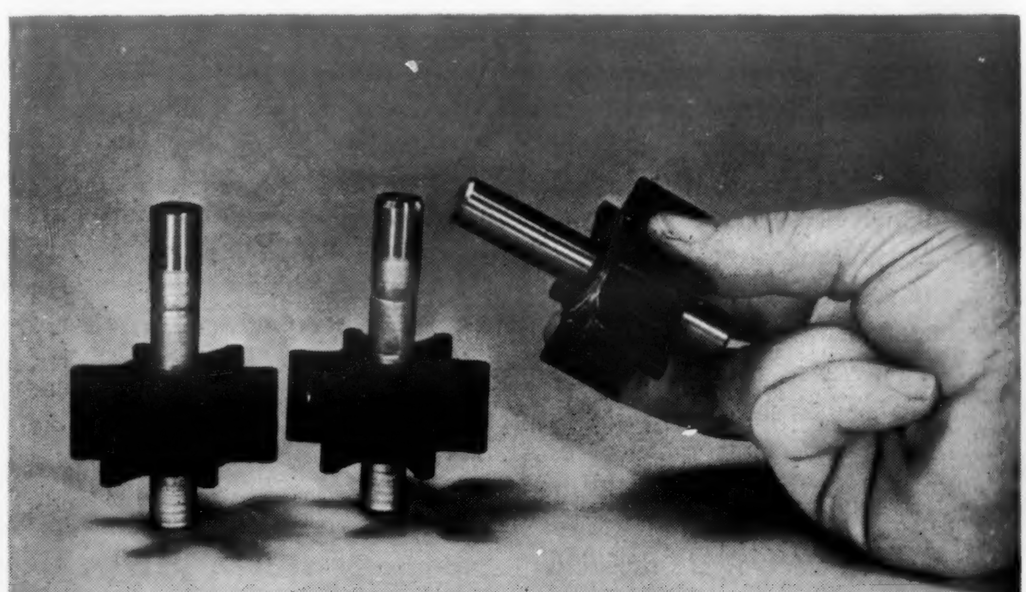
Rem-Cru Titanium, Inc.

Mixer for chlorine dioxide *is first large scale use of titanium in the paper industry. Mixer is lined with 1/8-in. commercial titanium sheet; the design was accepted because the titanium welds required had corrosion resistance equal to that of the base metal.*



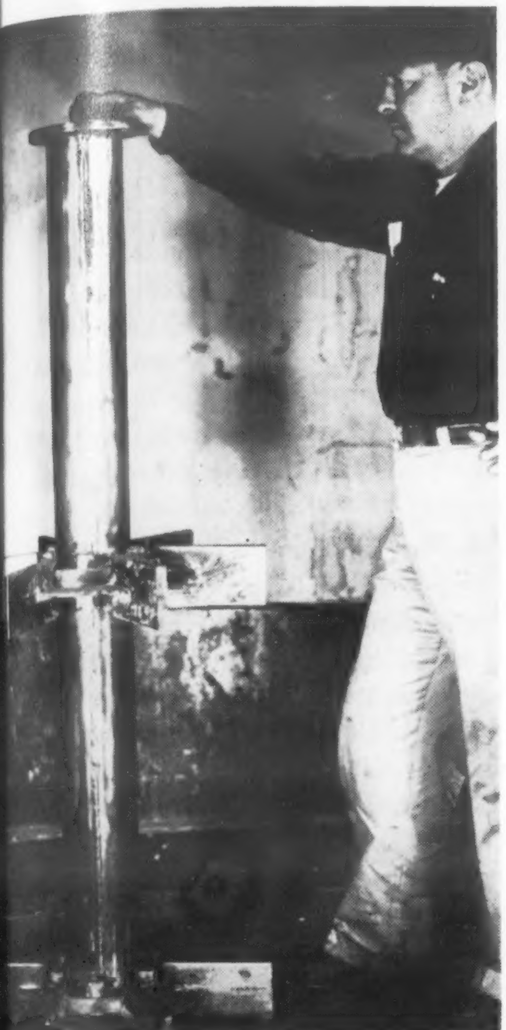
E. I. du Pont de Nemours & Co., Inc.

Condenser *handling 60% of nitric acid at 480 F and 300 psi is protected by titanium insert. Area was formerly subject to heavy corrosion; "top hat" has saved replacements and down-time.*



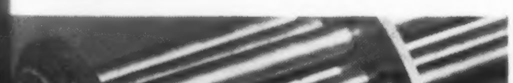
Mallory-Sharon Titanium Corp.

Shaft for ferric chloride pump *made of commercial titanium (right) is still in perfect condition after 320 hr operation. Shafts made of special ferrous and nonferrous alloys (left) operated only 45 min before pump leakage occurred.*



Rem-Cru Titanium, Inc.
Impeller *used by Calera Mining Co. for cobalt recovery operation. This titanium impeller operates in an autoclave containing 10 to 25% sulfuric acid solution at 600 psi pressure and 400 F.*

Johnston & Funk Titanium Corp.
Anodizing rack *made of titanium by Carlson Erie Corp. is serviceable for a much longer period than the aluminum racks used previously.*



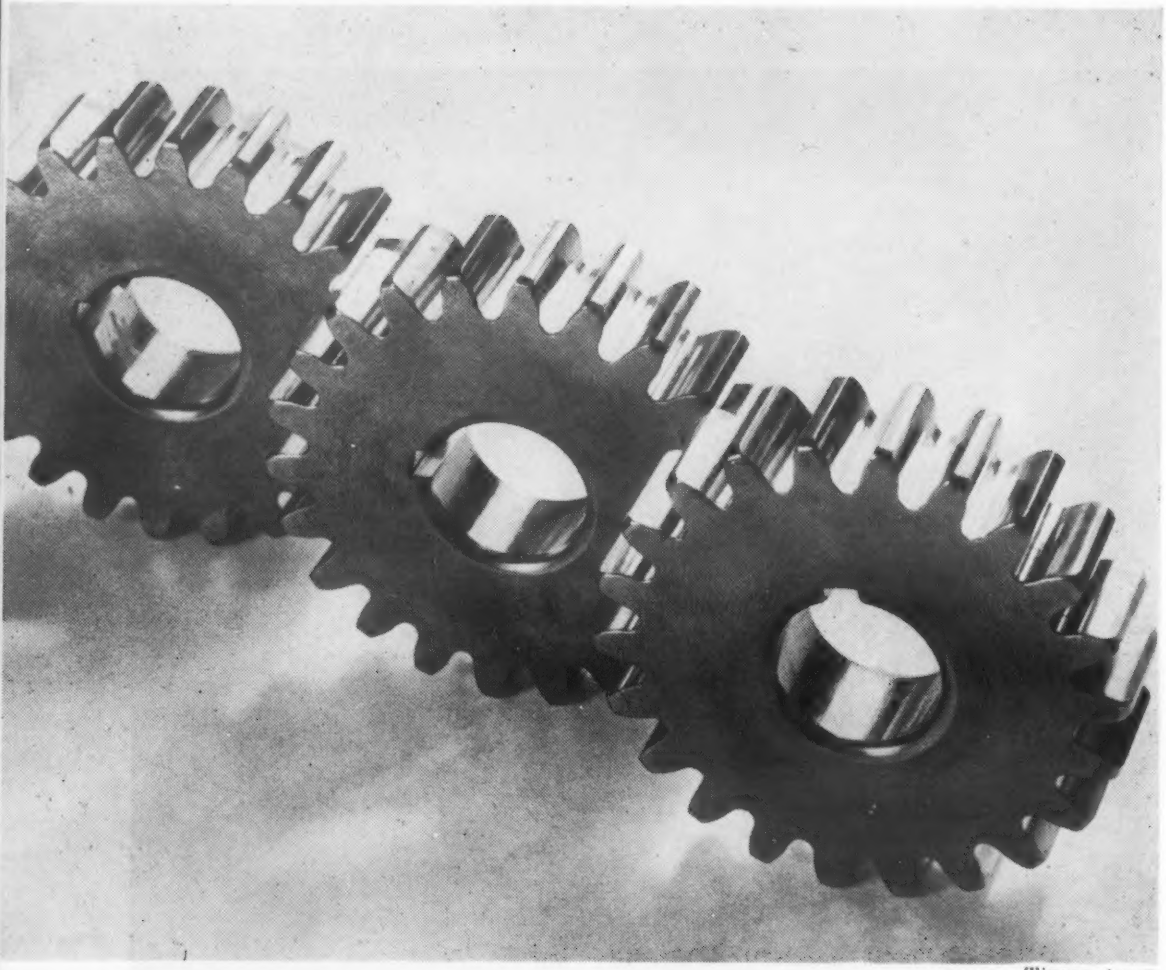
Mallory-Sharon Titanium Corp.
Heat exchanger *uses a 34-tube bundle of commercial titanium tubes to handle nitric acid vapors. Tube sheet is also made of titanium.*

hand some of the titanium alloys can be hardened (see table 5).

Additions of alloying elements to titanium stabilize either the alpha or beta modification. At present the only alpha stabilizers that occur in commercial materials are aluminum, oxygen, nitrogen and carbon. Of these, only aluminum is added intentionally, the others occurring as impurities. The only commercial alpha alloy is 5 Al-2.5 Sn; in this alloy the tin appears to be neutral, stabilizing neither alpha nor beta.

The remaining commercial alloys contain iron, chromium, vanadium, molybdenum and/or manganese in various combinations, each of which stabilizes the beta modification so that some of this phase is retained to or below room temperature. These alloys are mixtures of alpha and beta titanium. They are modified but not changed basically by the addition of elements that strengthen the alpha phase, such as aluminum, but benefits obtained from the alpha phase strengtheners are more apparent at elevated temperatures than at room temperature, i.e., alloys containing alpha strengtheners retain their strength at higher temperatures than alloys not containing these elements.

The commercial alloys have been divided by *McClintick*, Bauer and Busch into three groups on the basis of response to heat treatment: alpha alloys, marten-



Tiarco Corp.

Gears *of titanium show excellent resistance to galling and seizing after hard chromium plating.*

sitic alloys and metastable beta alloys.

1. *Alpha materials* — Unalloyed titanium and the 5 Al-2.5 Sn alloy are the only commercial materials produced in the United States that fit into the alpha titanium category. Imperial Chemical Industries produces a 13 Sn-2.75 Al alpha alloy. Since the beta phase cannot be retained in these materials at room temperature, they cannot be hardened by heat treatment. These materials are heat treated only to soften or to remove strains induced by cold working.

Commercial titanium is generally annealed in the range 1100 to 1350 F for periods that usually range, depending on section size, between 15 and 60 min. Air cooling from the annealing temperature is satisfactory. A stress relieving heat treatment of 30 min at 1000 F is recommended.

Since aluminum raises the recrystallization temperature, annealing of the alloy requires a higher temperature than is required for unalloyed titanium. Recommended anneal for this alloy is 1 hr at 1600 F. Cooling rate has no effect on properties. A stress relieving heat treatment of 1 to 2 hr at 1000 to 1200 F is satisfactory.

2. *Martensitic alloys* — All of the remaining commercial alloys, except 8 Mn, are martensitic alloys. At present they are generally used in the alpha-beta annealed condition.

Annealing temperatures range from 1150 to 1500 F, the alloys containing 5% or more aluminum being annealed at the upper end of the range because, as mentioned previously, aluminum raises the beta transus temperature. Stress relieving temperatures range from 1100 to 1300 F, and the time should be at least 30 min.

All of the martensitic alloys are potentially capable of being hardened by heat treatment, and much experimental work has been done on hardening methods. Only recently, however, have any of these alloys been hardened in commercial practice. So far, producers have recommended hardening procedures for only two of these alloys: 6 Al-4 V and 5 Al-2.75 Cr-1.25 Fe. The procedures are of the precipitation hardening type with solution temperatures in the 1400 to 1700 F range, followed by water quenching and aging at 900 to 1100 F for varying time periods.

3. *Metastable beta alloys*—The 8 Mn alloy is the only commercial alloy included in this category at present. To prevent embrittlement in this alloy, annealing at 1200 to 1300 F, followed by furnace cooling to 1000 F or lower, is recommended. Stress relieving can be done satisfactorily by holding at 1000-1100 F for 20 min and air cooling.

Although this alloy is capable of hardening by heat treatment, commercial procedures have not been developed.

Surface hardening—When titanium-base materials are heated to high temperatures in air, hardening occurs by absorption of oxygen and nitrogen. Investigation of various procedures has shown that titanium can be nitrided to form a useful case, but penetration of oxygen is so rapid that embrittlement of the core occurs.

Titanium can be nitrided by treatment either with pure nitrogen or with ammonia. However, the base metal is somewhat embrittled by both treatments. The cases formed have shown good wear resistance in tests. Carbonitriding by treating titanium with mixtures of propane and ammonia, or propane and nitrogen, also produces hard cases. These cases are essentially nitride cases, however, and have characteristics similar to those produced by nitriding.

Carburized cases have been produced by pack and gas methods. Best results were obtained by gas carburizing in a propane atmosphere. Shallow cases were satisfactory, but thick cases were brittle.

Joining

Joining titanium and its alloys is one of the more difficult procedures facing the fabricator of equipment. In commercial titanium, ductile joints can be obtained by resistance and inert-gas-shielded arc welding procedures. Good results have been obtained also by brazing and adhesive bonding, but soldering requires special techniques and is not particularly satisfactory.

Greater difficulties have been encountered in joining the alloys. At present, the flash-butt process seems to be the only welding process suitable for the commercial alloys, with the exception of 5 Al-2.5 Sn which can be joined by procedures suitable for commercial titanium. The alloys can be brazed to themselves or to dissimilar metals.

Welding—Because of its high affinity for hydrogen, oxygen and nitrogen, titanium can be welded successfully only by shielding the hot metal with a blanket of inert gas or by drastically restricting the time at the welding temperature. It has been shown that unalloyed titanium welds made by the tungsten arc prcess in a pure helium atmosphere have tensile, bend and impact properties comparable with those of the base metal. By contrast, addition of only 0.25% nitrogen or oxygen to the helium atmosphere was deleterious to the properties. These results indicate that a high purity shielding gas must be used to obtain satisfactory welds.

Carbon, nitrogen or oxygen in the base metal or filler rod also contribute to embrittlement of the weld. Based on bend ductility and notch toughness, the maximum quantity of these elements that can be tolerated in unalloyed titanium is 0.15% carbon, 0.07% nitrogen or 0.20% oxygen. If all three are present in the maximum quantities indicated, excessive embrittlement can be expected. The contents of these elements that can be tolerated in alpha-beta alloys depend on the beta content. Although data on hydrogen tolerances are limited, 150 ppm hydrogen appears to be the limit in alpha-beta alloys unless aluminum is present. In the latter alloys a greater tolerance for hydrogen appears practical.

Commercial titanium can be joined successfully using the inert-gas-shielded arc process. For this operation, however, all parts of the assembly that are heated above 1200 F must be shielded from contact with the air, either with an inert gas or by backing with a metal such as copper. The latter expedient has been used in welding thin sheet, as it assists in maintaining alignment. Uniformity is best if d.c. reverse polarity is used instead of a.c., but penetration and strength are equally good with either a.c. or d.c. Weld joints in the alpha alloys (commercial titanium and 5 Al-2.5 Sn) have mechanical properties similar to those of the base metal.

Filler rods of materials other than titanium are not satisfactory because extremely brittle welds result. Welding of the alpha-beta alloy grades by the inert arc process has not been so successful. Although the joints have been satisfactory, their ductility is low. Ductility can be improved by heat treatment in some alloys, specifically 6 Al-4 V and 3 Mn-1.5 Al

Spot welding of commercial titanium and 5 Al-2.5 Sn sheet offers no particular problem, and satisfactory welds can be made over a wide range of conditions. Weld time in cycles is about the same as that required for low carbon steel of the same thickness, but welding current is approximately 50% greater and from 25 to 50% more pressure on the electrode tips is desirable. Excessive penetration is characteristic of titanium spot welds, and in tests run by one organization no weld was made with less than 80% penetration. Since the welds are less ductile than the base metal, conditions should be adjusted by trial to limit penetration. However, an aircraft company reports that titanium readily meets the weld quality requirements for penetration, shear strength uniformity and soundness it had established for stainless steel sheet.

Flash-butt welding techniques for titanium resemble those used for aluminum alloys more closely than those used for steels. A relatively short flashing cycle is desirable, but it is also important to heat the weld far enough from the joint to allow sufficient upset for the expulsion of contaminated material during the forging cycle. Machines that are satisfactory for flash welding aluminum should be satisfactory for titanium.

Care is necessary at the beginning of flashing to prevent premature formation of joints. For heavy sections this is achieved by pointing the ends of the bars to concentrate the current when the arc is struck. In addition to commercial titanium, the alpha-beta alloys are joined commercially by flash-butt welding. Mechanical properties of the welds in these alloys are said to equal those of the parent metal.

Brazing—Titanium and its alloys can be brazed by ordinary furnace, torch, induction and resistance procedures, although special atmospheres and fluxes are required. Furnace and induction brazing can be done without fluxes in a vacuum or an inert atmosphere. In other procedures fluxes developed especially for titanium are required; these fluxes are generally mixtures of fluorides and chlorides in various percentages.

Strongest joints are obtained by using rapid heating cycles. Long brazing cycles cause excessive alloying between the titanium and the brazing alloy with the resultant formation of brittle phases at the joints. Consequently induction brazing is preferred to furnace brazing. The most satisfactory brazing alloys are those

containing silver. Fine silver itself is probably the most satisfactory filler metal; joints prepared with fine silver have better strength and ductility than those prepared with silver-base alloys.

Brazing can be used to join titanium to other metals such as mild and stainless steels, although precoating the steel or titanium with brazing filler metal may be required to obtain satisfactory joints. Joint strengths are lower than those obtained in joining titanium to itself.

Soldering—Only limited work has been done in this field. Conventional soldering methods are not satisfactory; however, titanium can be soldered if the joint area is precoated.

Adhesive bonding—Joining titanium by adhesive bonding does not appear to be a popular method in this country, although it has been employed in England. To assure good bonds, suitable surface preparation is necessary. Conversion coatings or anodized coatings have been suggested. However, lap joints of commercial titanium made by "Redux" resin bonding, after vapor degreasing and abrading, have withstood 100,000 psi before failure.

Mechanical fastening—Screws, nuts and bolts are produced from commercial titanium and several alloys. The galling and seizing that are characteristic of titanium make it difficult to run a nut on a bolt, however, and a coating of some type is recommended. A Teflon coating or a copper flash improves threading qualities.

Rivets are produced from commercial titanium, but alloy rivets have not been as successful. Riveting can be done on the same equipment that is used for driving aluminum alloy rivets. Close tolerance holes are required to obtain good upsetting of titanium rivets, and upsetting pressure is somewhat higher than that required for aluminum alloys.

Applications

Aircraft

Practically all of the titanium used today is being employed in some defense application. Major use, of course, is military aircraft, an application that has been discussed frequently during the past few years. Typical uses in the airframe are ducts, firewalls, shrouds, skins, ribs and fasteners; both commercial and alloy grades are used in the form of sheet, bar and forgings. The major use of titanium, however, is in jet engines for parts fabricated from bars or forgings, although some sheet is employed also. Parts include compressor components such as blades, rings and spacer housings.

This brief mention of the defense applications of titanium is no reflection on the importance of the field. Actually, the entire titanium industry depends, at present, on these uses. However, the future of titanium will be determined by the extent to which it wins acceptance in industrial applications.

At the present time the only important nonmilitary use of titanium is in commercial aircraft, in which the high strength-to-weight ratio gives the metal an advantage in spite of its high price. Applications include engine cowlings and firewalls. Use of the metal in commercial aircraft will probably increase with reductions in price, but quantity requirements can never be large enough to sustain the titanium producing industry.

Corrosion resistant equipment

The major future applications of titanium will probably be based on its excellent resistance to corrosion in certain environments. Recognizing this fact, the producers have put considerable effort during the past three years into the development of forms that have primary application in industrial fields. These include piping and pipe fittings in IPS sizes, spray nozzles, deep drawn large hemispheres, spun and disked cylindrical heads, wire cloth, valve and pump parts. Most of the work has been done on commercially pure titanium because it has better corrosion resistance than the alloys, because more is known about the effects of specific environments on its resistance, and because it can be more readily formed and joined.

Various installations of commercial titanium have been made in the chemical and process industries, and test data are being accumulated in plant operations. At present prices it appears that use of the metal on a commercial scale will be limited to applications in which other materials are grossly inadequate. However, quite a number of applications have been developed in which titanium is truly competitive. Some specific examples are:

1. Widespread use of titanium clips and racks in the anodizing of aluminum products. Titanium has a life many times as long as the aluminum clips and racks used previously. In addition, the titanium fingers do not become nonconducting during anodizing. Thus it is not necessary to strip the rack between cycles as when aluminum racks are used.

2. A titanium impeller operating in a mixture of organic chlorides, 3½% hydrochloric acid and free chlorine at 180 F has been in service for more than a year and is expected to have a useful life of several more years. A high nickel-chromium-molybdenum alloy, used previously, had a life of less than one year.

3. Titanium steam jet diffusers exposed to high velocity steam and dilute hydrochloric acid have been in service for 2½ years with no signs of corrosion. Cast iron, used previously, failed after three months' service.

4. A forged titanium valve has

Three important uses for titanium

Wyman Gordon Co.

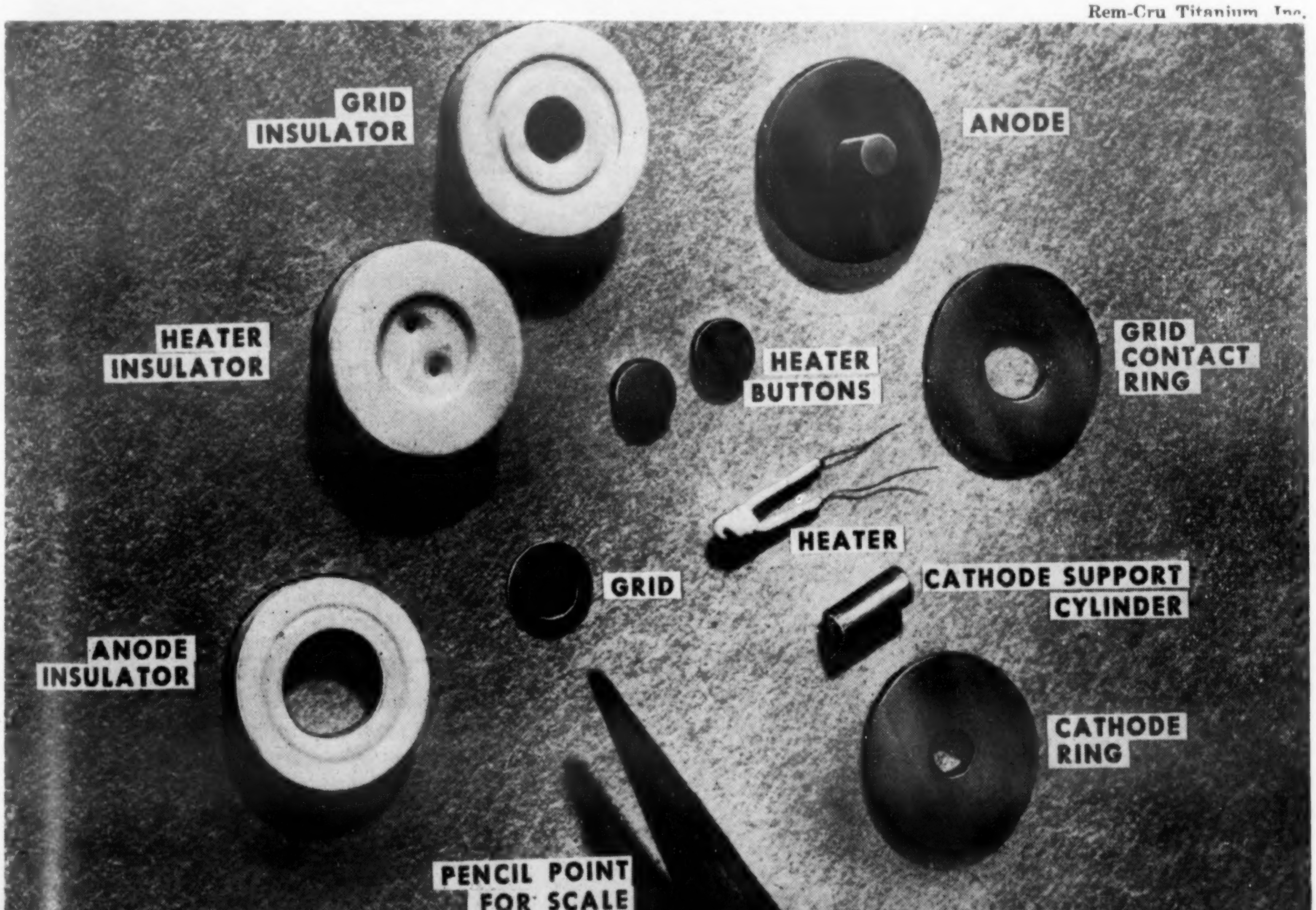
Lightweight structural parts. *This jet engine compressor hub was forged from titanium alloy 6 Al-4 V.*

Maxim Silencer Co.

Marine parts. *This wet type marine exhaust silencer was fabricated from titanium to take advantage of its excellent resistance to sea water corrosion. During welding all areas subjected to welding heat were flooded with inert gas.*

Electronic parts. *Heater buttons, cathode, plate and grid connections in General Electric's 6BY4 microminiature electronic tube are made of titanium because its thermal expansion matches that of the ceramic used for the other parts shown. Titanium parts also protect the cathode by acting as a getter for the oxygen and nitrogen remaining in the tube after sealing.*

Rem-Cru Titanium, Inc.



been used to handle a corrosive and erosive liquid at an inlet pressure of 3000 psi and a pressure drop across the valve of 2700 psi. This valve operated 1680 hr without overhauling. Under the same conditions a stainless steel valve required overhauling after 70 hr.

5. Titanium orifice plates in chlorine dioxide reactors have shown no corrosion in this service after exposure for a year; stainless steels pitted rapidly and a chromium-nickel-molybdenum alloy required replacement in 5 hr. Chlorine dioxide is used in pulping processes by several paper producers.

6. Titanium wire cloth assemblies are used with excellent results to filter calcium hypochlorite crystals in the presence of wet chlorine at a pressure of 3000 psi.

Electronic equipment

A new vacuum tube triode contains heater buttons, cathode, plate and grid connections made from titanium because of its thermal properties and because its coefficient of expansion matches that of the ceramic parts of the tube. This combination of properties makes it possible to operate the tube up to 950 F. The tube was designed for ultra high frequency television tuners and converters. Possible applications include radar and industrial power controls.

Titanium has a lower grid emission than most other metals, a property that would be useful in vacuum tubes. However, economic and technical problems prevent the commercial use of titanium grids.

Other applications

1. Marine applications should become a substantial market for titanium because of its excellent resistance to corrosion by sea water. However, little work has been reported in this field, probably because of economics. It has been reported that a small amount of titanium has been used for hardware on pleasure sail boats, and that valves and fittings have been tested on Navy vessels.

2. Titanium is used for bone plates, bone pins, splints and skull plates in orthopedic surgery. Braces and crutches for polio victims have also been made of titanium.

3. Small amounts of titanium are being used as gettering material in ultra high vacuum pumping systems.

Use of titanium in high speed centrifuges, in lightweight equipment for the process industries, and even in automotive and railroad car applications, sporting goods and business machines, has been suggested. Although an automobile "of the future" was built with the entire body constructed of commercially pure titanium sheet, the price will have to be reduced greatly before such applications become economically practical.

References

Achbach, W. P., "Forming of Titanium and Titanium Alloys," TML* Report No. 42, May '56.

Bishop, S. M., Spretnak, J. W., and Fontana, M. G., "Mechanical Properties Including Fatigue of Titanium-Base Alloys RC-130B and Ti-150A at Very Low Temperatures," *Trans Amer Soc Metals*, vol 45, 1953, p 993.

Bungard, K., and Rudinger, K., "Surface Hardening of Titanium by Nitrogen and Carbon," *Zeit Metallkunde*, Aug '56, p 377.

Colwell, L. V., and Truckenmiller, W. C., "Cutting Characteristics of Titanium and Its Alloys," *Mechanical Engineering*, June '53, p 461.

Deem, H. W., and Lucks, C. F., "Survey of Physical Property Data for Titanium and Titanium Alloys," TML* Report No. 39, Mar '56.

Durkin, A. E., "How to Descale Titanium," MATERIALS & METHODS, Oct '53, p 107.

Everhart, J. L., *Titanium and Titanium Alloys*, Reinhold Publishing Corp, 1954.

Finlay, W. L., and Wentz, W. W., "How to Heat Treat Titanium," MATERIALS & METHODS, June '56, p 126.

Fraser, G. T., Finlay, W. L., and Caterson, A. G., "Where Industry is Using Titanium," MATERIALS & METHODS, May '56, p 377.

Geil, G. W., and Carwile, N. L., "Effect of Low Temperatures on the Mechanical Properties of a Commercially Pure Titanium," *Jul of Research of National Bureau of Standards*, Feb. '55, p 1.

Hartbower, C. E., "Welding of Titanium, Titanium Metallurgy Course" New York Univ., Sept '56.

Holden, F. C., "Notch Sensitivity of Titanium and Titanium Alloys," TML* Report No. 69, Apr '57.

Jaffee, R. I., "A General Summary of the Physical Metallurgy of Titanium Alloys," TML* Report No. 19, Oct '55.

Lenning, G. A., and Jaffee, R. I. "Effect of Hydrogen on the Properties of Titanium Alloys," TML* Report No. 27, Dec '55.

Lewis, W. J., Faulkner, G. E., and Rieppel, P. J., "Brazing and Soldering of Titanium," TML* Report No. 45, June '56.

McClintick, R. J., Bauer, G. W. and Busch, L. S. *Physical Metallurgy and Heat Treatment of Titanium Alloys*, Mallory-Sharon Titanium Corp, '55.

Merchant, M. E., "Fundamental Facts on Machining Titanium," *Proc Titanium Symposium*, Watertown Arsenal, Oct '52, p 33.

Ripling, E. J., "Tensile Properties and Rheotropic Behavior of Titanium Alloys and Molybdenum," WADC Tech Report 55-5, Project No. 7351, May '55.

Stough, D. W., Fink, F. W., and Peoples, R. S., "The Corrosion of Titanium," TML* Report No. 57, Oct '56.

Stough, D. W., Fink, F. W., and Peoples, R. S., "The Oxidation of Titanium and Titanium Alloys," TML* Report No. 29, June '56.

Topelian, P. J., "New Chromium Plate for Aluminum and Titanium," MATERIALS & METHODS, May '56, p 120.

Whit, E. L., Miller, P. D., and Peoples, R. S., "Antigalling Coatings and Lubricants for Titanium, TML* Report No. 34, Feb '56.

*TML symbolizes the Titanium Metallurgical Laboratory of Battelle Memorial Institute. In addition to the reports mentioned specifically, information was obtained from several unnumbered memorandum reports of this organization.

Acknowledgments

The author gratefully acknowledges the assistance received from the personnel and publications of the following organizations in the preparation of this manual:

Babcock & Wilcox Co.
Battelle Memorial Institute
Boeing Airplane Co.
Brooks & Perkins, Inc.
Cambridge Wire Cloth Co.
Carpenter Steel Co., Alloy Tube Div.
Cincinnati Milling Machine Co.
E. I. du Pont de Nemours & Co.
Electro Metallurgical Co.
Harvey Aluminum Div.
Johnston & Funk Titanium Corp.
Mallory-Sharon Titanium Corp.
Maxim Silencer Co.
North American Aviation, Inc.
Oregon Metallurgical Corp.
Rem-Cru Titanium, Inc.
Republic Steel Corp.
Superior Tube Co.
Tiarco Corp.
Titanium Metals Corp. of America
Voi-Shan Mfg. Co.
Vulcan Mfg. Div.
Worcester Pressed Steel Co.
Wyman-Gordon Co.

Reprints of this Manual are available at 35¢ each until supply is exhausted. *See page 214 for complete list of available Manuals.* *Write for quotations on quantities of 100 or more. Address Reader Service Dept.,* MATERIALS IN DESIGN ENGINEERING, *430 Park Ave., New York 22, N. Y.*

Here is a comparison of . . .

British and American Standard Steels

Compiled by W. B. Kemmish, *Consulting Metallurgist with Dr. R. Genders, London, England*

■ The British Standards Institution functions as a coordinating body between producers and consumers, and the standards issued are the result of collaboration between experts from both sides of industry. The most frequently used steel standard in general engineering is BS 970, "Wrought steels for general engineering purposes." This general standard comprises a range of engineering and constructional steels designated as En steels. It is widely used in industry as a logical foundation for material specification and purchase.

An American metallurgist taking an initial look at the range of compositions specified in this standard may feel that the choice of steels is somewhat restricted when compared with the large number listed in the SAE standards. However, the basis upon which the specifications have been drawn up differs in some important respects from that used for the SAE series. Reference to BS 970 will show that a typical En specification not only stipulates the limits for the chemical composition of the steel, but also 1) indicates the form in which the steel should normally be supplied and the tensile strength ranges for which it is suitable, and 2) gives details of mechanical test requirements covering tensile strength, yield or proof stress, ductility and impact resistance after any necessary working or prescribed heat treatment processes have been applied. Both chemical and physical tests must be satisfied if the material is to comply with the specification requirements. The physical property requirements are related to the ruling section of the bar or component at the time of heat treatment in such a manner that the recommended tensile strength ranges for each steel are clearly indicated. The relationships among chemistry, section thickness and strength are recognized in the specifications, and failure of a steel to give satisfactory mechanical properties despite correct chemistry renders it subject to rejection.

Six Pages of Data

The comparison of British and American standard steels is given in tabular form. The first three pages appear in this issue (pp 173, 175 and 177). The concluding three pages will appear in next month's issue (November). Footnotes for all data pages appear on this page.

The chemical limits for most En steels are wider than those for comparable SAE steels, and the carbon range is generally about 0.10%. However, the increasing use of specialized heat treatments in industry has led to the introduction of a series of subspecifications for certain steels which provide closer control of steel composition, and carbon ranges of 0.05%. In these cases the supplier is freed of liability in respect of mechanical test requirements, and the purchaser is thus provided with the opportunity to obtain steels in a manner similar to that practiced in the United States.

The comparison tables

For convenience the accompanying tables have been divided into groups of carbon steels, alloy steels, corrosion and heat resisting steels, and steels for special applications such as deep drawing and spring manufacture. The comparisons have been based on chemical composition, and the endeavor has been to make them as precise as possible. There are, of course, quite a number of British steels without counterparts in the SAE series and vice versa. In any particular section, the absence of an SAE steel indicates that there are no compositional counterparts, although several SAE steels could possibly be selected which would give comparable mechanical properties. The mechanical properties quoted in the tables for the En steels are the values given in the various specifications as minima or ranges; properties given for SAE steels are typical values.

Steels containing boron, or steels of controlled hardenability characteristics, are not the subject of BS specifications, but generally they may be obtained by arrangement with suppliers if specially required. However, in most cases it is possible to provide a suitable alternative from the regular En series, thus avoiding the costs incidental to special melts.

Footnotes to tables

[a] Subdivisions of En 8 provide steels similar to SAE 1035, 1038 and 1042.

[b] Subdivisions of En 8M provide steels similar to SAE 1137, 1138, 1140 and 1141.

[c] Available in three ranges having carbon limits within 0.05%.

[d] Available in four ranges having carbon limits within 0.05%.

[e] See also En 40.

[f] Available as four subdivisions.

[g] Mo+Se+Pb limited to 1.0% max. Individual max as given in table.

[h] Ni+Cr not less than 25%.

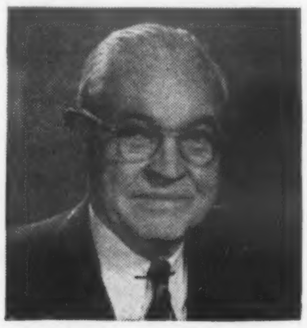
[i] Ni+Cr not less than 25%.

[j] Ni+Cr not less than 23%.

(continued on p 173)

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



Technical-ities

By John S. Davey

Nuts — their use and abuse

With bolts tightened to high load levels, nut performance becomes critical.

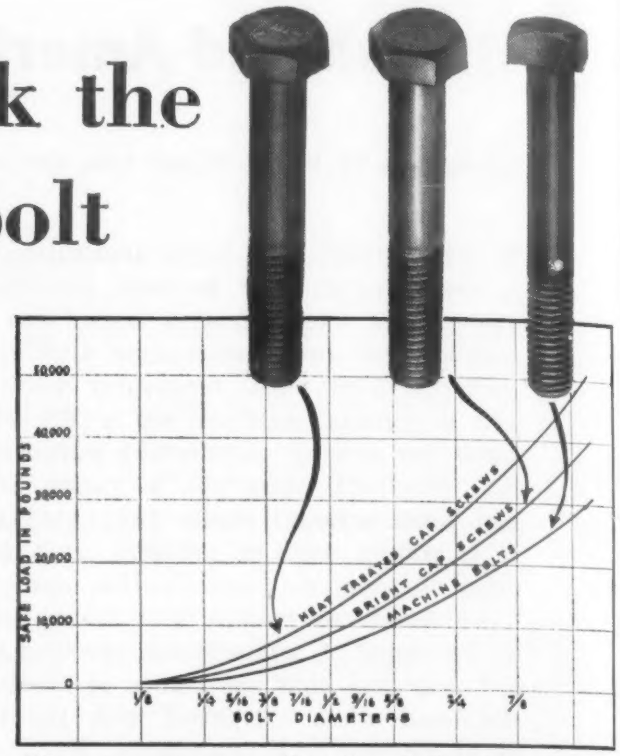
A nut produces bolt tension by rotating and advancing on the bolt threads. To do this, there must be a mating condition of threads, which is influenced by thread lead. Lead is a matter of tolerance only before bolt is stressed. When tightened, the nut is then under compression and threads tend to contract; the bolt is in tension, and threads tend to stretch. Lead of thread is affected—elastically *before* yield point, permanently *beyond* it.

This shortening of one lead and lengthening of the other has two effects. (1) The load distributes unequally along the threads (2) Torsion on bolt increases. Something has to give. For high tensile bolts especially, it is better for the nut to do so. A nut therefore should be soft enough so that it deforms plastically and compensates for off-lead. If it does, it *distributes* the load and can advance to increase tension.

"SOFT" NUTS DO MOST JOBS

"Soft" nuts do adjust more readily than hard ones under these severe conditions. While such nuts may not be as strong in shear as heat treated ones, the important point is the bolt tension they produce. As long as the nut can pull the bolt well into its plastic range, it is doing more than its share of the job.

How to pick the right size bolt



When it comes to uniformity of dimension, quality of head and thread, and ease of assembly, all RB&W cold headed fasteners are the same. They differ mainly in tensile strength as shown here.

Almost all bolt and cap screw strength requirements can be satisfied from three types of *standard* fasteners without recourse to costly special alloys. In the widely used middle range of sizes, the problem is one of deciding which makes the best joint, or which proves the most economical for the job.

MORE FOR LESS

Suppose, for example, you need a bolt safe for 20,000 pounds of loading. As the chart shows, you could use an RB&W 7/8" square-head bolt, a 3/4" bright cap screw, or a 5/8" heat treated one.

If you have a lot of holes to fill, use the larger, lower strength fasteners. But to cut down number of bolts, or their size (and therefore cost), go to the higher tensiles. However you gain nothing if you don't tighten high tensile bolts to their full strength.

HOW COSTS COMPARE

In terms of holding power: For each $1.00 in high tensile bolts, it costs $1.50 to provide equivalent clamping force with bright cap screws; or $1.65 with machine bolts.

For more suggestions on fastener economy or for copy of above curves, write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N.Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Spin-Lock Nuts dig in to stay tight

The photograph shows the many hardened "anchors" on the flange of a Spin-Lock Nut. These "ratchet-action" teeth require 20% more torque to loosen than to tighten. They bite in as the nut turns down on its seat. Like Spin-Lock Screws, these nuts can stay put in products subject to vibration and cyclic temperature variations. Send for bulletin.

For more information, turn to Reader Service card, circle No. 595

FILE FACTS

British and American Standard Steels—continued

Designation	Composition, %							Cond	Heat Treat Temp, F			Quench Medium	Mechanical Properties			
	C	Si	Mn	Ni	Cr	Mo	Other		Carburize	Harden	Temper		Ten Str, 1000 psi	Elong, %	Brinell Hardness	Ruling Section, in.
FREE MACHINING AND CARBON STEELS																
En 1A	0.07-0.15	—	0.8-1.2	—	—	—	0.2-0.3 S,	CD.......	—	—	—	—	52-72	14-10	110-140	—
							0.07 P	HT.......	1620-1710	1400-1440	—	Water	63 min	20 min	125	—
En 1B	0.07-0.15	—	1.0-1.4	—	—	—	0.3-0.6 S,	CD.......	—	—	—	—	52-61	12-10	110-120	—
							0.06 P	HT.......	1620-1710	1400-1440	—	Water	63 min	20 min	125	—
								HR.......	—	—	—	—	52 min	24 min	110	—
SAE 1113	0.13 max	—	0.7-1.0	—	—	—	0.24-0.33 S	CD.......	—	—	—	—	58-78	20-10	115-150	—
							0.07-0.12 P									
En 32	0.15 max	—	0.4-0.7	—	—	—	0.05S, 0.05 P	HT.......	1620-1710	1400-1440	—	Water	72 min	20 min	140	—
SAE 1015	0.13-0.18	—	0.3-0.6	—	—	—	0.05S, 0.04 P	HR.......	—	—	—	—	56	33	110	—
								CD.......	—	—	—	—	69-85	25-15	140-170	—
SAE 1010	0.08-0.13	—	0.3-0.6	—	—	—	0.05S, 0.045 P	HR.......	—	—	—	—	56	35	110	—
								CD.......	—	—	—	—	65	25	125	—
En 32M	0.10-0.18	—	0.9-1.2	—	—	—	0.1-0.15 S	HT.......	1620-1710	1400-1440	—	Water	72 min	20 min	140	—
							0.05 P									
SAE 1114	0.10-0.16	—	1.0-1.3	—	—	—	0.08-0.13 S,	HR.......	—	—	—	—	56	33	110	—
							0.045 P	CD.......	—	—	—	—	67	25	130	—
En 7	0.1-0.3	—	0.7-1.3	—	—	—	0.10-0.18 S	CD.......	—	—	—	—	78-101	15 min	150-210	—
							0.06 P									
SAE 1120	0.18-0.23	—	0.7-1.0	—	—	—	0.08-0.13 S,	HR.......	—	—	—	—	67	30	130	—
							0.045 P	CD.......	—	—	—	—	78	20	150	—
En 202	0.18 max	—	1.1-1.5	—	—	—	0.10-0.18 S,	HT.......	1620-1710	1420-1450	—	Water	85 min	20 min	170	1
							0.05 P									
En 7A	0.12-0.18	—	1.0-1.5	—	—	—	0.10-0.18 S,	HR.......	—	—	—	—	63 min	25 min	120	—
							0.06 P	CD.......	—	—	—	—	67-101	15 min	130-210	—
SAE 1118	0.14-0.20	—	1.3-1.6	—	—	—	0.08-0.16 S,	HR.......	—	—	—	—	67	42	130	—
							0.045 P	CD.......	—	—	—	—	90	20	180	—
En 2	0.2 max	—	0.8 max	—	—	—	0.06 S, 0.06 P	HR.......	—	—	—	—	45 min	28 min	—	—
					—	—		A........	—	1620-1670	—	—	45 min	28 min	—	—
SAE 1015	0.13-0.18	—	0.3-0.6	—	—	—	0.05 S, 0.45 P	HR.......	—	—	—	—	58	33	115	—
								CD.......	—	—	—	—	68-85	25-15	140-170	—
En 3	0.25 max	—	1.0 max	—	—	—	0.06 S, 0.06 P	HR.......	—	—	—	—	59-78	25 min	110-150	—
En 3B, 3D	0.25 max	—	1.0 max	—	—	—	0.06 S, 0.06 P	CD.......	—	—	—	—	63 min	17 min	120	—
En 3C	0.17-0.23	—	0.6-1.0	—	—	—	0.05 S, 0.05 P	N........	—	1620-1670	—	—	63 min	25 min	120	—
SAE 1022	0.18-0.23	—	0.7-1.0	—	—	—	0.05 S, 0.04 P	HR.......	—	—	—	—	61	31	120	—
								CD.......	—	—	—	—	85	6	170	—
En 4	0.3 max	—	1.1 max	—	—	—	0.06 S, 0.06 P	N........	—	1560-1650	—	—	63-85	25 min	126-179	—
En 4A	0.3 max	—	1.1 max	—	—	—	0.06 S, 0.06 P	CD.......	—	—	—	—	72-94	12 min	140-190	—
SAE 1025	0.22-0.28	—	0.3-0.6	—	—	—	0.05 S, 0.04 P	HR.......	—	—	—	—	67	28	130	—
								CD.......	—	—	—	—	81	20	160	—
En 5	0.25-0.35	—	0.6-1.0	—	—	—	0.06 S, 0.06 P	HT.......	—	1580-1630	1020-1220	Oil	62-101	27-20	131-255	—
En 5B	0.28-0.33	—	0.7-0.9	—	—	—	0.06 S, 0.06 P	—	—	—	—	—	—	—	—	—
En 5D	0.25-0.35	—	0.6-1.0	—	—	—	0.06 S, 0.06 P	HT & CD	—	—	—	—	78-101	20-15	229-255	—
SAE 1030	0.28-0.34	—	0.6-0.9	—	—	—	0.05 S, 0.04 P	HR.......	—	—	—	—	74	26	150	—
								CD.......	—	—	—	—	85	19	175	—
								HT.......	—	1600	900	Water	90	28	185	—

(continued on p 175)

For more information, turn to Reader Service card, circle No. 447

FILE FACTS

British and American Standard Steels—continued

Designation	Composition, %							Cond	Heat Treat Temp, F			Quench Medium	Mechanical Properties			
	C	Si	Mn	Ni	Cr	Mo	Other		Carburize	Harden	Temper		Ten Str, 1000 psi	Elong, %	Brinell Hardness	Ruling Section, in.
FREE MACHINING AND CARBON STEELS—Continued																
En 6	0.40 max	—	0.5-0.9	—	—	—	0.06 S, 0.06 P	CD......	—	—	—	—	72-108	10 min	140-220	—
SAE 1035	0.32-0.38	—	0.6-0.9	—	—	—	0.05 S, 0.04 P	HR......	—	—	—	—	83	25	170	—
								CD......	—	—	—	—	90	20	180	—
								HT......	—	1550	1310	Water	85	34	175	—
								HT......	—	1550	860	Water	105	32	215	—
En 8[a]	0.35-0.45	—	0.6-1.0	—	—	—	0.06 S, 0.06 P	HT......	—	1525-1580	1020-1220	Oil	90-101	20 min	179-255	½-2½
								CD......	—	—	—	—	83-94	10 min	241 max	—
SAE 1040	0.37-0.44	—	0.6-0.9	—	—	—	0.05 S, 0.04 P	HR......	—	—	—	—	90	24	180	—
								CD......	—	—	—	—	99	18	200	—
En 8M[b]	0.35-0.45	—	0.9-1.3	—	—	—	0.12-0.20 S,	HT......	—	1525-1580	1020-1220	Oil	90-101	20 min	179-255	½-2½
							0.06 P	CD......	—	—	—	—	85 min	12 min	229 max	—
SAE 1140	0.37-0.44	—	0.7-1.0	—	—	—	0.08-0.13 S,	HR......	—	—	—	—	90	24	180	—
							0.045 P	CD......	—	—	—	—	99	18	200	—
En 9	0.5-0.6	—	0.5-0.8	—	—	—	0.06 S, 0.06 P	HT......	—	1490-1540	1020-1220	Oil	101-123	15 min	200-302	1⅛-2
								CD......	—	—	—	—	112-146	12 min	223-302	—
SAE 1055	0.5 0.6	—	0.6-0.9	—	—	—	0.05 S, 0.04 P	N.......	—	—	—	—	105	20	215	—
LOW CARBON STEELS FOR COLD FORMING OPERATIONS																
En 2A/1	0.10 max	—	0.5 max	—	—	—	0.04 S, 0.04 P	—	—	—	—	—	—	—	—	—
SAE 1006	0.08 max	—	0.25-0.4	—	—	—	0.05 S, 0.04 P	—	—	—	—	—	—	—	—	—
SAE 1008	0.10 max	—	0.25-0.5	—	—	—	0.05 S, 0.04 P	—	—	—	—	—	—	—	—	—
En 2A	0.12 max	—	0.05 max	—	—	—	0.05 S, 0.05 P	—	—	—	—	—	—	—	—	—
SAE 1010	0.08-0.13	—	0.3-0.6	—	—	—	0.05 S, 0.04 P	—	—	—	—	—	—	—	—	—
En 2B	0.15 max	—	0.5 max	—	—	—	0.05 S, 0.05 P	—	—	—	—	—	—	—	—	—
SAE 1015	0.13-0.18	—	0.3-0.6	—	—	—	0.05 S, 0.04 P	—	—	—	—	—	—	—	—	—
En 2C	0.15-0.25	—	0.4-0.6	—	—	—	0.05 S, 0.05 P	—	—	—	—	—	—	—	—	—
SAE 1020	0.18-0.23	—	0.3-0.6	—	—	—	0.05 S, 0.04 P	—	—	—	—	—	—	—	—	—
MANGANESE STEELS																
En 201	0.18 max	—	1.1-1.5	—	—	—	0.05 S, 0.05 P	HT......	1620-1710	1420-1450	—	Oil or water	85 min	20 min	—	—
En 202	0.18 max	—	1.1-1.5	—	—	—	0.1-0.18 S,	HT......	1620-1710	1420-1450	—	Oil or water	85 min	20 min	—	—
							0.05 P									
SAE 1114	0.1-0.16	—	1.0-1.3	—	—	—	0.08-0.13 S,	HR......	—	—	—	—	56	35	110	—
							0.045 P	CD......	—	—	—	—	67	22	130	—
SAE 1116	0.14-0.20	—	1.1-1.4	—	—	—	0.16-0.23 S,	HR......	—	—	—	—	60	35	120	—
							0.045 P	CD......	—	—	—	—	78	20	150	—
En 14A	0.15-0.25	—	1.3-1.7	—	—	—	0.06 S, 0.06 P	HT......	—	1540-1650	1020-1220	Oil or water	90-101	20 min	179-255	2½
SAE 1320	0.18-0.23	—	1.6-1.9	—	—	—	0.04 S, 0.04 P	HT......	—	1580	1080	Water	101	25	210	—
En 14B	0.20-0.30	—	1.3-1.7	—	—	—	0.06 S, 0.06 P	HT......	—	1540-1620	1020-1220	Oil or water	90-101	20	179-255	—
SAE 1330	0.25-0.33	—	1.6-1.9	—	—	—	0.04 S, 0.04 P	HR......	—	—	—	—	101	25	210	—
								HT......	—	1540	1000	Oil	139	20	277	1
En 15	0.30-0.40	—	1.3-1.7	—	—	—	0.05 S, 0.05 P	HT......	—	1540-1620	1020-1220	Oil	101min	20 min	201-255	2½
SAE 1335	0.33-0.38	—	1.6-1.9	—	—	—	0.05 S, 0.05 P	HR......	—	—	—	—	108	25	220	—
								HT......	—	1540	1000	Oil	130	17	262	2

(continued on p 177)

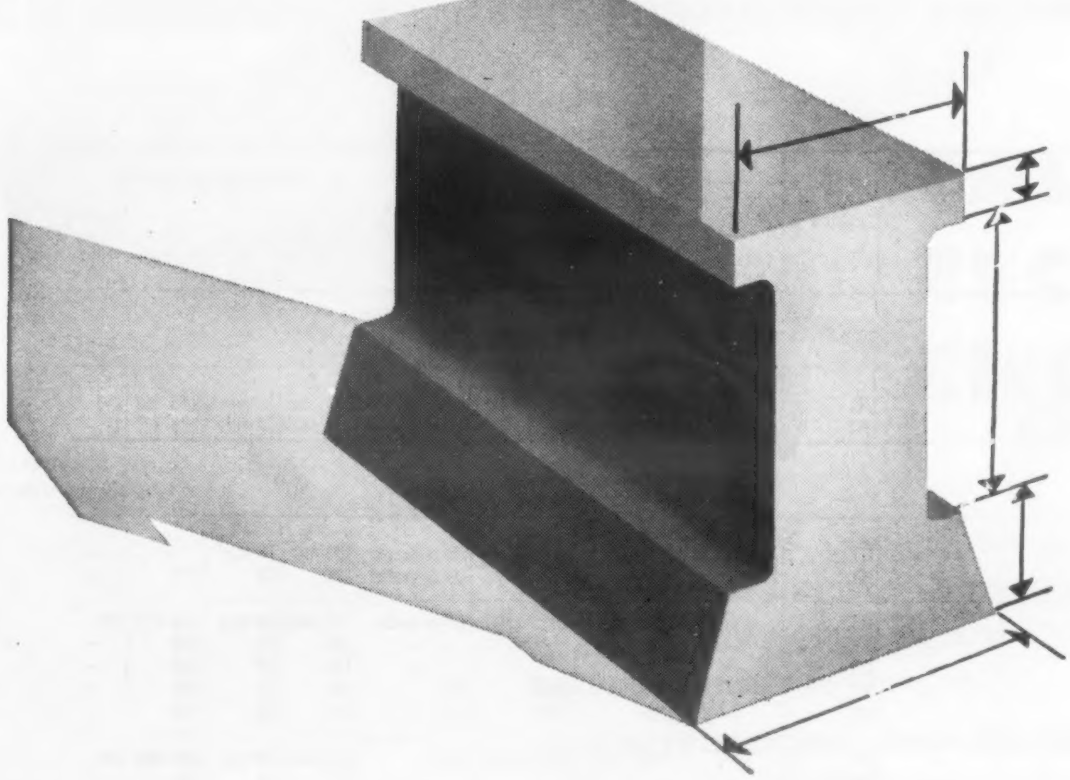
FILE FACTS

British and American Standard Steels—continued

Designation	Composition, % C	Si	Mn	Ni	Cr	Mo	Other	Cond	Heat Treat Temp, F Carburize	Harden	Temper	Quench Medium	Mechanical Properties Ten Str, 1000 psi	Elong, %	Brinell Hardness	Ruling Section, in.
MANGANESE-MOLYBDENUM STEELS																
En 16°	0.30-0.40	—	1.3-1.8	—	—	0.2-0.35	—	HT......	—	1525-1580	1020-1220	Oil	123 min	18 min	248-302	2½
En 17	0.30-0.40	—	1.3-1.8	—	—	0.35-0.55	—	HT......	—	1525-1580	1020-1220	Oil	134 min	17 min	269-321	2½
NICKEL STEELS																
En 33	0.10-0.15	—	0.3-0.6	2.75-3.5	0.3 max	—	—	HT......	1620-1710	1400-1440	—	Oil or water	101 min	18 min	—	—
SAE 2317	0.15-0.20	—	0.4-0.6	3.25-3.35	—	—	—	HT......	1700	—	300	Oil or water	134	18	270	—
En 21	0.25-0.35	—	0.35-0.75	2.75-3.25	0.3 max	—	—	HT......	—	1525-1560	1020-1200	Oil or water	112 min	20 min	223-277	2½
SAE 2340	0.28-0.33	—	0.6-0.8	3.25-3.75	—	—	—	HR......	—	—	—	—	105	21	215	—
								CD......	—	—	—	—	123	12	250	—
								HT......	—	1525	1000	Oil	128	23	260	—
								HT......	—	1525	800	Oil	159	18	320	—
En 22	0.35-0.45	—	0.5-0.8	3.25-3.75	0.3 max	—	—	HT......	—	1525-1580	1020-1200	Oil	123 min	18 min	248-302	2½
SAE 2340	0.38-0.43	—	0.7-0.9	3.25-3.75	—	—	—	HR......	—	—	—	—	114	19	240	—
								N......	—	—	—	—	105	22	215	—
								HT......	—	1510	1000	Oil	136	21	280	—
								HT......	—	1510	800	Oil	179	17	370	—
En 37	0.16 max	—	0.45 max	4.5-5.2	0.3 max	—	—	HT......	1620-1710	1380-1440	—	Oil	90-134	20 min	—	—
SAE 2512	0.09-0.14	—	0.45-0.6	4.75-5.25	—	—	—	HR......	—	—	—	—	90	28	180	—
								CD......	—	—	—	—	114	25	235	—
								HT......	1700	—	300	Oil	168	20	350	—
En 38	0.16 max	—	0.6 max	4.5-5.5	0.3 max	0.15-0.3	—	HT......	1620-1710	1580-1440	—	Air or oil	145 min	13 min	—	—
SAE 2515	0.12-0.17	—	0.4-0.6	4.75-5.25	—	—	—	HR......	—	—	—	—	105	27	210	—
								CD......	—	—	—	—	140	25	285	—
								HT......	1700	—	300	Oil	180	18	370	—
NICKEL-CHROMIUM STEELS																
En 111	0.30-0.40	—	0.6-0.9	1.0-1.5	0.45-0.75	—	—	HT......	—	1510-1560	1020-1200	Oil	100-134	17-22	200-320	1-6
SAE 3135	0.33-0.38	—	0.6-0.8	1.1-1.4	0.55-0.75	—	—	HT......	—	1540	1000	Oil	148	18	300	—
En 24	0.35-0.45	—	0.45-0.7	1.3-1.8	0.9-1.4	0.2-0.35	—	HT......	—	1510-1560	1220 max	Oil	112-224	8-20	223-444	1⅛-6
SAE 3141	0.38-0.43	—	0.7-0.9	1.1-1.4	0.7-0.9	—	—	HT......	—	1510	1000	Oil	165	15	330	1
En 23	0.25-0.35	—	0.45-0.7	2.75-3.5	0.5-1.0	0.65 max	—	HT......	—	1510-1650	1020-1220	Oil	112-145	16-20	223-341	2½-6
En 36B	0.12-0.18	—	0.3-0.6	3.0-3.75	0.6-1.1	—	—	HT......	1620-1710	1400-1440	–	Oil	145 min	13 min	300 min	—
SAE 3316	0.14-0.19	—	0.45-0.6	3.25-3.75	1.4-1.75	—	—	HR......	—	—	—	—	134	17	270	—
								A......	—	—	—	—	105	26	210	—
								HT......	1700	—	250	Oil	208	15	420	—
En 39A	0.12-0.18	—	0.5 max	3.8-4.5	1.0-1.4	—	—	HT......	1620-1710	1400-1440	400 max	Oil	140 min	12 min	390 min	—
								A......	—	—	—	—	124	25	277 max	—
En 30A	0.26-0.34	—	0.4-0.6	3.9-4.3	1.1-1.4	—	—	HT......	—	1490-1530	480 max	Air or oil	224 min	10 min	444	—
								A......	—	—	—	—	134	20	277 max	—

(more British and American Standard Steels next month)

Cost per clamp cut from $1.06 to 58¢ with J&L hot extruded cold drawn section



This manufacturer cut the cost of contact clamps 45% by converting to J&L extruded sections. Previous cost of $1.06 per part involved costly milling and scrap loss from cold drawn 1½" x 1" flats.

Here's how extruded sections can cut your cost:

1. Eliminate machining and finishing operations.
2. Reduce scrap losses almost to zero.
3. Eliminate cost of casting and forging intricate sections.
4. Reduce inventories because extrusions are quickly available.

Investigate this new production technique for your shape profiles—within present limits of a design which can be inscribed in a three-inch circle. Available in a wide range of carbon and alloy steels. For specialty alloy and tool steels, submit inquiry. Get complete details by writing to the Jones & Laughlin Steel Corporation, Dept. 474, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

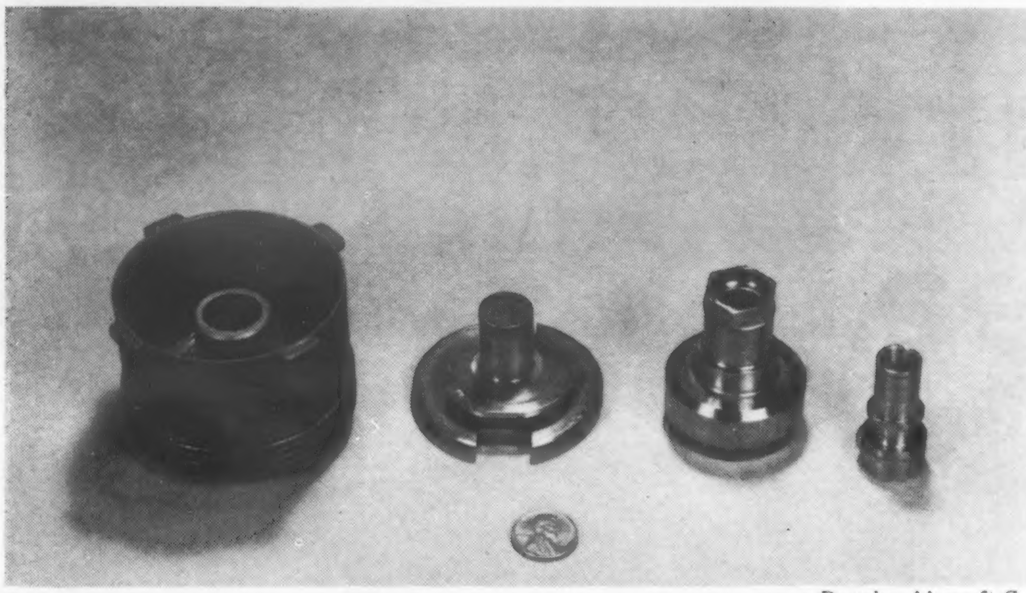
Jones & Laughlin

STEEL . . . a great name in steel

For more information, turn to Reader Service card, circle No. 424

What's new IN MATERIALS

Contents



Douglas Aircraft Co.

Cylinder and piston parts *of bomb ejector are forged of Ti-155A.*

Titanium Alloy Has Guaranteed Tensile Strength of 170,000 Psi

■ Titanium alloy Ti-155A, originally developed in 1953, is now available from Titanium Metals Corp. of America, 233 Broadway, New York 7, with a guaranteed heat treat capability of 170,000 psi tensile strength. It is claimed to be one of the strongest titanium alloys available in the mill annealed condition and is offered in the form of forging billets, bars, extrusions, rolled shapes and wire. It is readily machined and finished but is not considered weldable.

Mechanical properties

Annealed—In the mill annealed condition, Ti-155A possesses excellent strength and ductility as a result of a duplex-phase microstructure consisting of alpha and beta, each of which is solid solution-strengthened with alloying additions. The alpha phase is strengthened with aluminum, and the beta phase with iron, chromium and molybdenum (see Table 1). Guaranteed minimum room temperature mechanical properties of mill annealed Ti-155A bar and billet in section sizes up to 1½ in. are: tensile strength, 145,000 psi; 0.2% offset yield strength, 135,000 psi; elongation, 10%; and reduction in area, 20%. Typical room temperature mechanical properties are given in Table 2.

Heat treated—A duplex type heat treatment (discussed later) is responsible for what are claimed to be the highest guaranteed minimum mechanical properties in any titanium alloy. Guaranteed and typical mechanical properties are given in Tables 3 and 4.

At high temperatures—Elevated temperature properties of both heat treated and annealed Ti-155A are plotted in Fig 1. As shown, tensile strengths in the annealed condition are in excess of 100,000 psi at temperatures up to 800 F. In the heat treated condition, tensile strengths over 120,000 psi are possible at temperatures up to

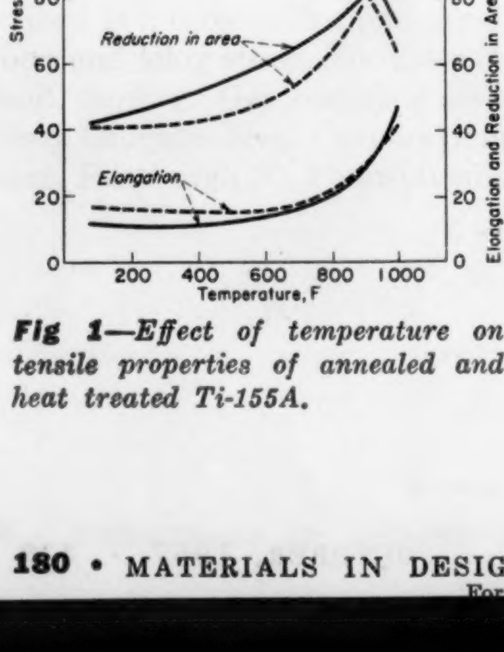


***Fig 1**—Effect of temperature on tensile properties of annealed and heat treated Ti-155A.*

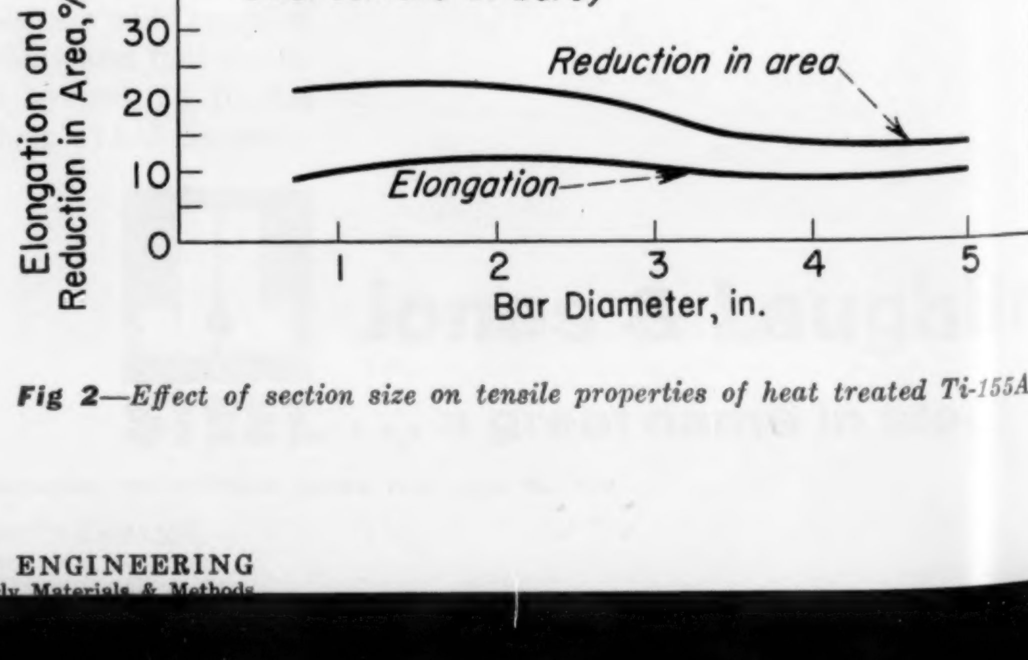


***Fig 2**—Effect of section size on tensile properties of heat treated Ti-155A.*

TABLE 1—COMPOSITION OF Ti-155A (%)

Aluminum	5.0-6.0
Iron	1.1-1.7
Chromium	1.1-1.7
Molybdenum	0.9-1.5
Carbon	0.08 max
Nitrogen	0.05 max
Hydrogen	0.0125 max (bar)
	0.0100 max (billet)

TABLE 2—TYPICAL MECHANICAL PROPERTIES OF ANNEALED Ti-155A[a]

IN TENSION	
Ultimate Strength, 1000 psi	155
Yield Strength, 1000 psi	
0.2% Offset	140
0.1% Offset	135
Elongation (in 1 in.), %	15
Reduction in Area, %	35
Notched Strength, 1000 psi[b]	200
Modulus of Elasticity, 10^6 psi	16.5
IN COMPRESSION	
Yield Strength, 1000 psi	
0.2% Offset	144
0.1% Offset	138
0.02% Offset	117
0.01% Offset	112
Modulus of Elasticity, 10^6 psi	19.5
IN TORSION	
Ultimate Strength, 1000 psi	127
Yield Strength, 1000 psi	
0.2% Offset	92
0.1% Offset	87
Total Twist to Failure	365°
Rigidity or Shear Modulus, 10^6 psi	6.3
OTHER	
Rockwell Hardness	C36
Charpy Impact (-40 F), ft-lb	14

[a]Tensile tests performed on specimens from ½-in. dia bar; compression and torsion specimens from 1-in. dia bar.
[b]60-deg V-notch, 0.005 in. root radius, 0.5 ratio notched-to-unnotched area.

TABLE 3—GUARANTEED HEAT TREAT CAPABILITY OF Ti-155A BAR AND FORGING STOCK[a]

UP TO 1-IN. SECTION	
Tensile Strength, 1000 psi	170
Yield Strength (0.2% offset), 1000 psi	155
Elongation (in 4 dia), %	
Longitudinal	10
Transverse	8
Reduction in Area, %	
Longitudinal	20
Transverse	15
1 TO 2-IN. SECTION	
Tensile Strength, 1000 psi	160
Yield Strength (0.2% offset), 1000 psi	145
Elongation (in 4 dia), %	
Longitudinal	8
Transverse	6
Reduction in Area, %	
Longitudinal	15
Transverse	12
2 TO 3½-IN. SECTION	
Tensile Strength, 1000 psi	150
Yield Strength (0.2% offset), 1000 psi	135
Elongation (in 4 dia), %	
Longitudinal	8
Transverse	6
Reduction in Area, %	
Longitudinal	12
Transverse	10
3½ TO 5-IN. SECTION	
Tensile Strength, 1000 psi	140
Yield Strength (0.2% offset), 1000 psi	130
Elongation (in 4 dia), %	
Longitudinal	8
Transverse	6
Reduction in Area, %	
Longitudinal	12
Transverse	10

[a]Heat treatment: 1 hr at 1650 F, water quenched, aged 6 hr at 1000F, air cooled. Recommended maximum forging temperature is 1750 F.

TABLE 4—TYPICAL MECHANICAL PROPERTIES OF HEAT TREATED Ti-155A BAR[a]

IN TENSION	
Ultimate Strength, 1000 psi	180
Yield Strength, 1000 psi	
0.2% Offset	173
0.1% Offset	165
Elongation (in 1 in.), %	15
Reduction in Area, %	25
Notched Strength, 1000 psi[b]	245
Modulus of Elasticity, 10^b psi	17
IN COMPRESSION	
Yield Strength, 1000 psi	
0.2% Offset	182
0.1% Offset	174
0.02% Offset	161
0.01% Offset	156
Modulus of Elasticity, 10^6 psi	19.5
IN TORSION	
Ultimate Strength, 1000 psi	146
Yield Strength, 1000 psi	
0.2% Offset	111
0.1% Offset	104
Total Twist to Failure	130
Rigidity or Shear Modulus, 10^6 psi	6.6
OTHER	
Rockwell Hardness	C40
Charpy Impact (-40 F), ft-lb	12

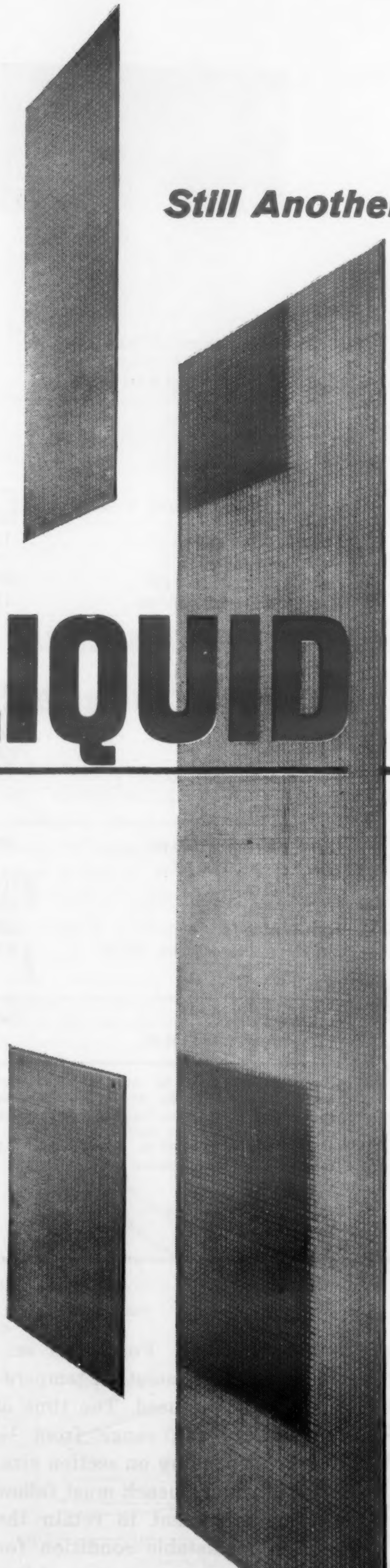
[a]Heat treatment: 1 hr at 1625 F, water quenched, aged 24 hr at 1000 F. Tensile specimens from ½-in. dia bar; compression and torsion specimens from 1-in. dia bar.
[b]60-deg V-notch, 0.005-in. root radius, 0.5 ratio notched-to-unnotched area.

800 F. Other properties at these temperatures include: Poisson's ratio, 0.358; modulus of elasticity, 13.1 x 10^6 psi; and modulus of rigidity, 4.8 x 10^6 psi.

Heat treatment

Titanium alloy Ti-155A can be strengthened by heat treatment because of the fact that lean beta present at temperatures high in the alpha-beta field can be retained in a metastable condition upon quenching to room temperature. When reheated to the aging temperature, this metastable beta transforms to a strong matrix of fine alpha and solid solution-strengthened stable beta.

Optimum heat treatments for Ti-155A consist of solution treating, water quenching and aging. For bars and forgings having cross sections of 1 in. and less, a solution temperature of 1650 F is recommended. For larger sections, a 1700 F solution temperature should be used. The time at temperature can range from ½ to 2 hr, depending on section size. A rapid water quench must follow solution treatment to retain the beta in metastable condition for maximum aging response. After water quenching, the alloy is aged at 1000 F to obtain high strengths



Still Another **AMERICAN** *First!*

WINDSOR FELTS FOR

LIQUID FILTRATION

OUTLAST ALL OTHER FILTER MATERIALS 10 to 1

Windsor Felts are unique, fiber bonded, non-woven structures, engineered to serve as economical and efficient filter media for industrial processing. Quick facts:

- **Greater product recovery**
- **Easy cake release**
- **Can be hosed off without taking from press**
- **Can be re-used indefinitely**
- **Produce less plugging**
- **Do not shrink, are ravel-free and produce clean-cut edges**
- **Reduce leakage**
- **Have unusual stability**
- **Temperatures to 250F**

These outstanding properties make Windsor Felts highly suitable for use on plate and frame, pressure leaf, rotary vacuum, cartridge or specialty filters.

The Engineering and Research Division invites your inquiry and will be pleased to work with you on your specific filtration problem and make recommendations.

For the newest in economical filter material send for Data Sheet #18 WINDSOR FELT-LIQUID FILTRATION, making request on your firm's letterhead.

American Felt Company

TRADE MARK

GENERAL OFFICES: 24 GLENVILLE ROAD, GLENVILLE, CONN.

SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Greenville, S.C., Dallas, Boynton Beach, Fla., San Francisco, Los Angeles, Portland, San Diego, Seattle, Montreal.—**PLANTS:** Glenville, Conn.; Franklin, Mass.; Newburg, N.Y.; Detroit, Mich.; Westerly, R.I.—**ENGINEERING AND RESEARCH LABORATORIES:** Glenville, Conn.

For more information, turn to Reader Service card, circle No. 454

at an acceptable level of ductility. Aging temperatures of 1050 and 1100 F can be employed to produce a higher level of ductility, but strength levels are somewhat reduced. An aging time of 6 hr is recommended to establish optimum mechanical properties within a thermally stable microstructure.

Effect of section size—An important aspect in the heat treatment of any material is the extent to which heavy sections may be strengthened. In alpha-beta titanium alloys the depth of hardenability is governed by the depth to which metastable beta can be retained during cooling from the solution temperature. This is a function of the beta-stabilizing alloy content and the rate of cooling.

Ti-155A owes much of its position as a leading heat treatable alloy to the fact that after water quenching from the solution temperature it can be strengthened throughout relatively heavy forged sections. Fig 2 shows tensile properties obtained on specimens taken from the centers of bars of various diameters after heat treatment. As section size increases heat treated strength decreases, and at 3 in. the tensile strength is in the neighborhood of 160,000 psi. In sections greater than 3 in. strengths gradually decrease to the annealed strength level of small diameter bar stock.

Most extensive use of the new alloy thus far has been in forgings for aircraft applications such as propeller blades, vanes and hubs for jet engines, and cylinder and piston parts of bomb ejectors (see photo, p 180).

Immersion Bath Produces Uniform Gold Coatings on Metals

Trophies, *printed circuits and other products can be gold coated with a new immersion gold solution.*

■ An immersion gold solution called Atomex is claimed to deposit a 24-carat gold coating on copper, cadmium, zinc, nickel, iron, steel and other metals by means of a simple bath. Developed by Baker & Co., Inc., Engelhard Industries, 113 Astor St., Newark 2, N. J., the solution consists of an organic gold complex. According to the producer, the gold plating bath requires no electrical current or special equipment to effect a proper finish. A container and a heat source are said to be the only equipment necessary.

Its advantages

The gold immersion solution is said to produce a denser, better looking coating, with 25% less gold, than gold electroplates. It is also said to adhere more firmly to most metals than gold electroplates.

Because there is no free cyanide or carbonate build-up, the company claims that analytical control of the bath is not needed. As a result, small operators do not need the services of a consultant to check their baths periodically. All the gold in the bath can be consumed and the spent solution is thrown away rather than sent

back to the manufacturer for refining.

How it works

The gold coating is deposited on metals by a replacement process. When an object to be coated is placed in a heated gold solution bath, the surface of the basis metal goes into solution and is replaced by atoms of gold from the bath. According to the producer, there are no low or high density areas in the coating and all parts of the object, even blind recesses, receive a uniform deposit.

The immersion solution is self-limiting and automatically stops coating when a certain weight or thickness has been reached. A usual coating weighs about 1 mg per sq in. and is about 0.000003 in. thick. Iron, die cast metals, carbon steel and soft solder require a 3-min immersion at 140 F to deposit 1 mg of gold per sq in. on a part; at 194 F it takes 1.5 min to gold coat these metals. To gold coat nickel, a 15-min immersion at 140 F is required. Nickel, however, can be gold coated in less time when the bath temperature is raised to 194 F. To coat copper the pH of the bath should be between 7 and 8 and the temperature between 110 and 170 F; the gold will not deposit on copper when bath temperature exceeds 170 F.

In general, parts to be gold coated with the dipping process are cleaned in the same way as parts to be electroplated. Copper printed circuit boards should be scrubbed with wet pumice or proprietary cleansing powders.

Where to use it

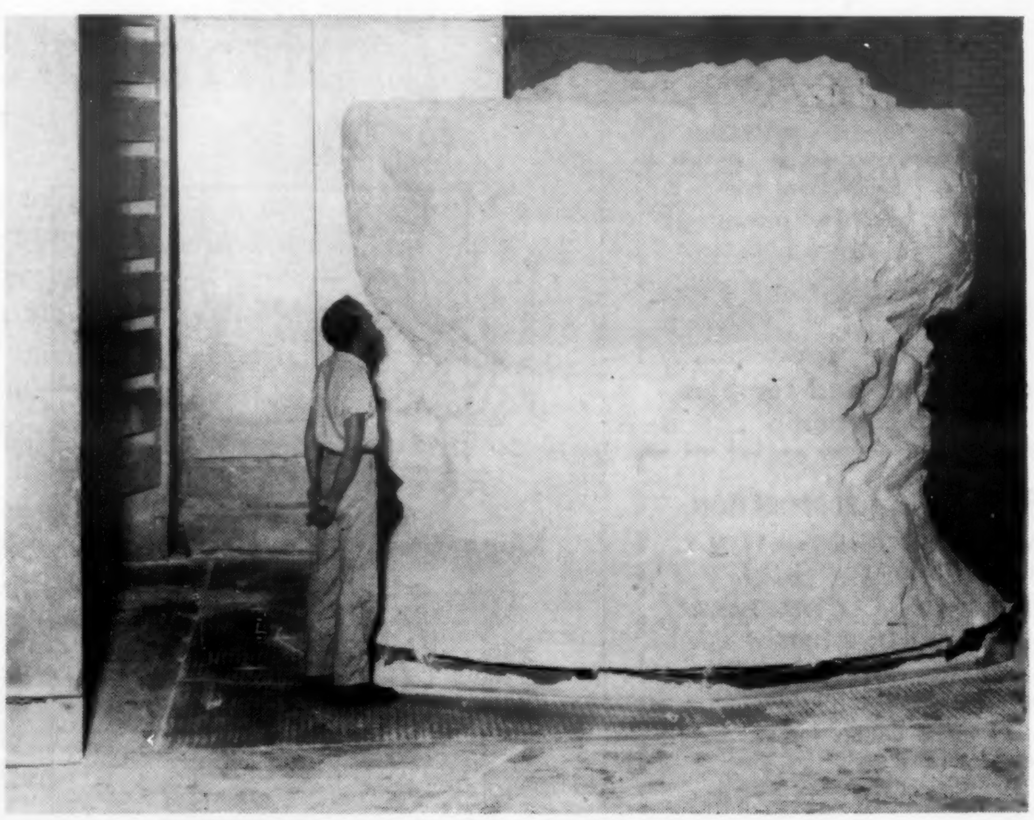
The gold immersion solution is recommended for depositing gold coatings on such items as trophies, costume jewelry, printed electrical circuits, auto trim, lamp components, clock assemblies, photograph frames, perfume and whiskey bottle caps, radio knobs and electrical plug connectors.

In addition to their decorative applications, the gold coatings can be used to protect metal surfaces that are to be soldered. For example, copper foil printed circuits are said to retain their solderability for 12 to 18 months when protected with a replacement gold coating. In some applications the gold coating itself can be used as a solder between such metals as tungsten and nickel.

Atomex Immersion Gold solution is packaged in units of 200 cc gold concentrate containing ½ oz (troy) of fine gold.

(more What's New on p 186)

Largest synthetic mica melt—This huge mass of material is reported to be the largest synthetic mica melt ever made. According to the producer, Synthetic Mica Corp., more than 80,000 lb of raw materials were used in its production. The mass of crystalline mica was cooled for approximately three weeks, broken up, then ground into usable form. The company reports that it has produced synthetic mica crystals as large as 4 by 4 in.—it hopes to produce larger crystals in this melt. Experiments in the control of furnace operations and cooling to produce large crystals are currently being evaluated.



What's new IN MATERIALS

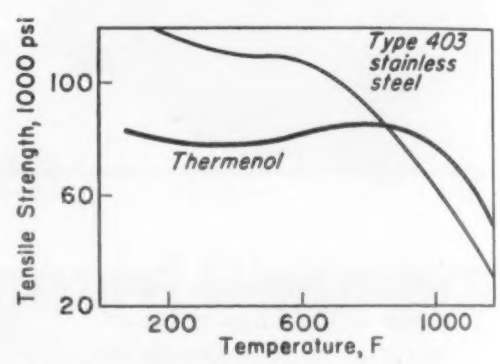
Iron-Aluminum Magnetic Alloy Has Excellent Heat Resistance

■ A relatively new, nonstrategic, high temperature magnetic alloy does not decrease rapidly in tensile strength with an increase in temperature like other high temperature alloys—in fact, the alloy shows a slight increase in tensile strength at various high temperature levels.

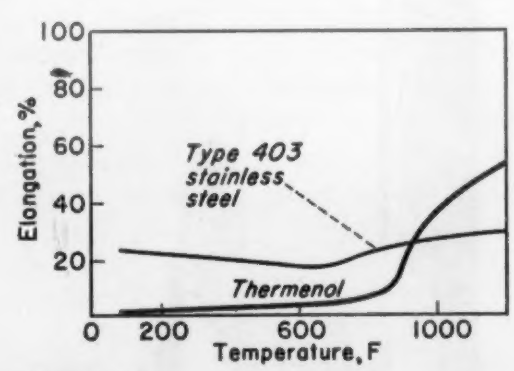
Since June, 1954, when the alloy was first made known by the Naval Ordnance Laboratory, a great amount of interest has been shown in its use in compressor blades for high speed aircraft. Some scientists say that the alloy, an iron-aluminum alloy called Thermenol, is better than titanium and as good as stainless steel. Thermenol won't creep or turn soft at temperatures up to 1200 F, whereas titanium and its alloys usually soften at a temperature of 800 F. However, stainless steel stays firm at temperatures up to 1700 F.

Recently, the Laboratory released more detailed information

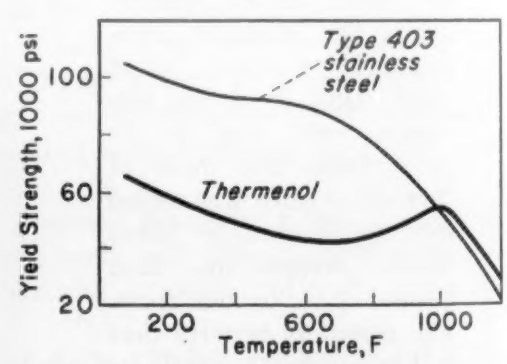
How Thermenol compares with stainless steel



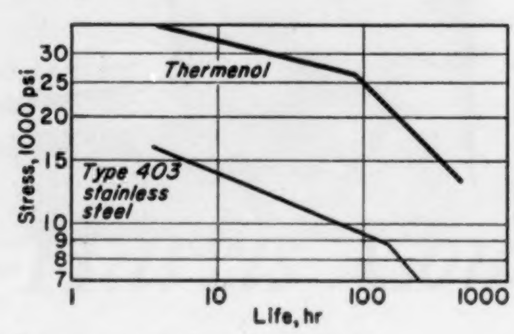
Tensile strength



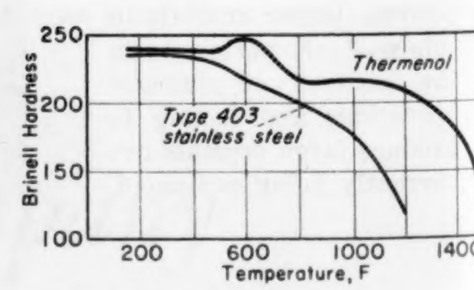
Elongation



Yield strength



Stress-rupture at 1200 F



Hot Brinell hardness

PYROTAC

Automatic protection against temperature damage

Just as a fuse protects electrical circuits against overloads, the Alnor Pyrotac automatically protects furnaces, kilns and other heating equipment against damage due to excessive temperatures.

This low-cost, easily installed instrument can be added to any automatic or manually controlled equipment and give continuous protection...safeguard your investment in equipment, controls and material in process.

Highest Alnor quality throughout, the Pyrotac features Alnico magnet, double air-gap movement that is standard in all Alnor pyrometers...laboratory precision...industrial ruggedness which assures top reliability.

Write today for complete details on the Pyrotac, available in eight scale ranges from 0-600° F. and 0-3000° F. Ask for Bulletin 2002. Illinois Testing Laboratories, Inc., Room 522, 420 North LaSalle St., Chicago 10, Illinois.

Alnor

ALNOR PRECISION INSTRUMENTS
FOR EVERY INDUSTRY

For more information, turn to Reader Service card, circle No. 379

on the alloy. Navord Report No. 4237 includes both room and high temperature data on the alloy's hardness, tensile strength, stress-rupture properties, and corrosion and oxidation resistance. The investigators, J. F. Nachman and W. J. Buehler, of the Laboratory, also discuss a number of military and commercial applications for a material of this type.

How it performs

Since preliminary studies show that it may be possible for Thermenol to replace type 403 stainless steel as a compressor blade material, most of the data in the report compare the properties of Thermenol with those of type 403. What the investigators found is summarized below:

1. *Physical properties.* The physical and mechanical properties of Thermenol compare favorably with those of type 403 stainless steel (see graphs). Thermenol has better stress-rupture properties at 1200 F than stainless steel, and 15% lower density. At room temperature the alloy has an ultimate tensile strength of 142,800 psi. It has fatigue strengths of 61,000 to 66,000 psi in the unnotched condition, compared with 56,000 to 65,000 psi for type 403 stainless steel under similar conditions. The two investigators found that the presence of notches in Thermenol specimens does not influence fatigue failure.

At 1000 F, ultimate tensile strength of type 403 stainless steel drops to approximately one-half of the room temperature value, whereas Thermenol actually increases in tensile strength. According to the researchers, the rise in strength is partly due to an order-disorder transformation

TYPICAL COMPOSITION OF THERMENOL (%)

Aluminum	16.50
Molybdenum	3.40
Carbon	0.06
Mischmetal	0.10
Iron	79.94

DUTCH BRAND PLASTIC TAPE

for every electrical need!

From high line to cable vault Dutch Brand Plastic Electrical Tape meets the requirements of the job. It has high dielectric strength, over 1000 volts per mil of thickness, with stretch to conform neatly and smoothly to irregular shapes. It protects against corrosion, is weatherproof, waterproof, rot, mildew and fungus proof. Linemen and electricians know the value of dependable tape . . . and tape economy.

That's why they insist on safe, easy-to-use Dutch Brand Plastic Tape for every electrical maintenance, production and construction job. Available in the sizes and widths to meet every requirement.

***Write for booklet**—In the market for new ideas on tape as a time-and-money-saver? Send for "Big Four in Electrical Tapes," our new booklet. Write today!*

Johns-Manville Dutch Brand Products
7800 South Woodlawn Avenue
Chicago 19, Illinois

JOHNS-MANVILLE JM PRODUCTS

DUTCH BRAND

JOHNS-MANVILLE

For more information, turn to Reader Service card, circle No. 592

in the alloy and partly to an increase in ductility.

2. *Magnetic properties.* Composition greatly affects magnetic properties of the alloy, and tests show that good magnetic properties are obtained with a Thermenol type alloy containing 15 to 16 aluminum, 3 to 4 molybdenum, and 80% iron.

3. *Corrosion resistance.* Thermenol is more resistant to salt spray than heat treated type 403 stainless steel. Corrosive attack on Thermenol occurs on the whole surface; stainless steel undergoes a severe pitting type of corrosion. At high temperatures, Thermenol has oxidation resistance superior to that of all other known high temperature alloys. Thermenol has good resistance to common chemical solutions and is fully resistant to oxidizing solutions, organic acids and food products. At high temperatures, the alloy has excellent resistance to oxidizing and sulfur-bearing atmospheres.

4. *Fabrication.* The iron-aluminum alloy can be rolled, forged and extruded into bars and shapes.

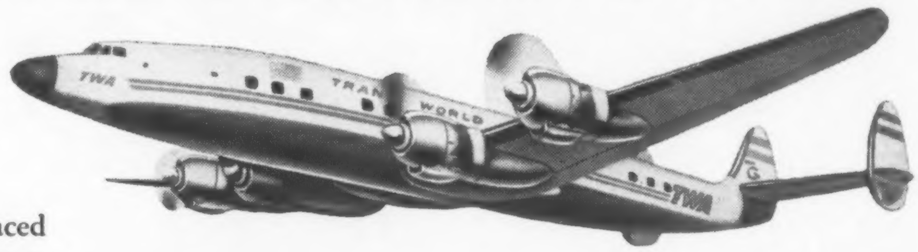
5. *Joining.* The alloy can be welded to both mild and stainless steel by fusion and resistance welding techniques. High temperature brazing alloys containing nickel as a base cause embrittlement of the alloy.

6. *Machining.* All ordinary machining operations, e.g., turning, threading, drilling, milling, shaping and tapping, can be performed satisfactorily on Thermenol if sharp tools and slow speeds are used. Since Thermenol tends to work harden very rapidly, excessive speeds should be avoided.

Some potential uses

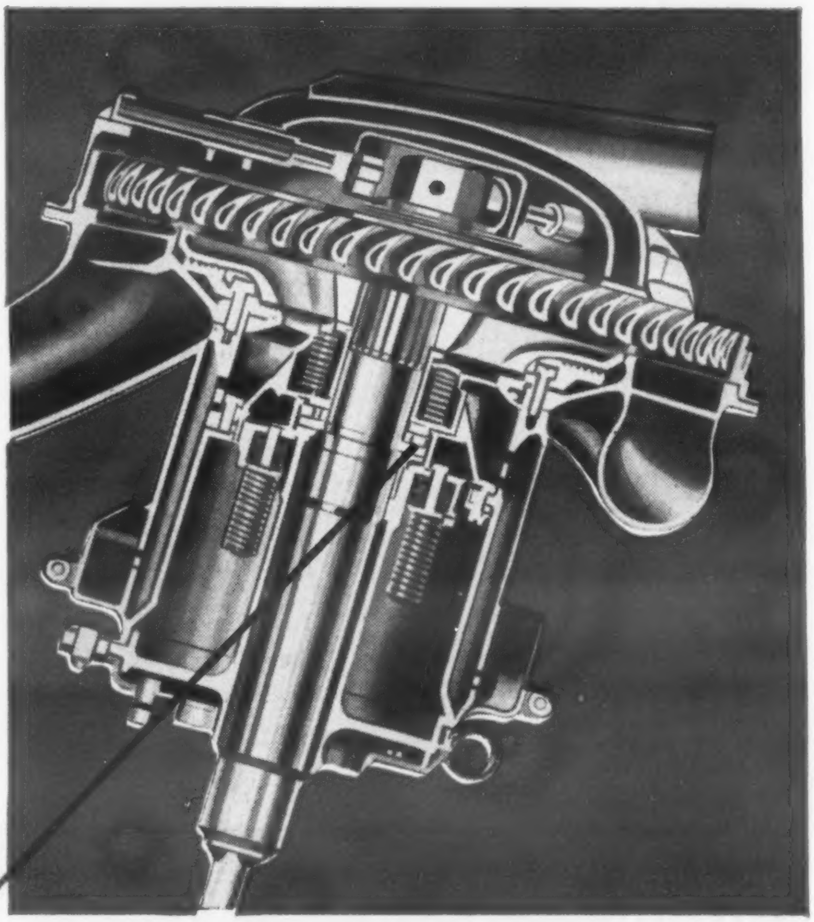
In addition to its potential use as a jet engine compressor blade material, the alloy should find use in skins for supersonic missiles and aircraft; heating elements in large industrial furnaces; kitchen equipment; containers for liquid rocket fuels; and magnetic tape

GRAPHITAR® OIL SEALS PLAY IMPORTANT PART IN DEPENDABLE PERFORMANCE OF NEW POWERFUL CURTISS-WRIGHT TURBO COMPOUND ENGINES

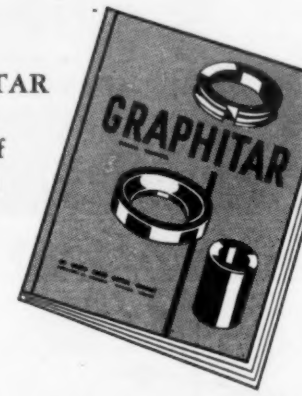


Increased demands for faster non-stop service has placed great demands on the engines that power modern airliners. Helping to meet this need is the powerful EA Series Turbo Compound engines built by the Wright Aeronautical Division of the Curtiss-Wright Corporation, Wood-Ridge, New Jersey. In each of these 18-cylinder giant engines, 3 GRAPHITAR oil seals play an important part in maintaining the dependability, efficiency and power. Three power-recovery units are employed on the Turbo Compound to utilize normally wasted exhaust gases and provide still additional thrust. The GRAPHITAR seals are used on the turbine shaft in each of these units and must withstand continuous high speeds and high temperatures. These seals prevent hot gases from reaching the shaft bearings and carbonizing the lubricant. Low coefficient of friction, and the excellent wear and sealing properties of GRAPHITAR make it ideally suited for this demanding installation.

Compacted under extreme pressure, and fused at heats to 4500° F., GRAPHITAR can be formed into relatively complex shapes, ground to tolerances as close as .0005″. Since it is entirely self-lubricating, GRAPHITAR can be used where only steam or water are present. GRAPHITAR is lightweight, durable, chemically inert and virtually unaffected by extremes of vibration, pressure, or temperature.



Get the fact-filled GRAPHITAR engineering Bulletin No. 20. Write today for your copy. If you have design questions on problems, our engineering staff will be happy to assist you in any way possible.



R-248-1

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® SINTERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

For more information, turn to Reader Service card, circle No. 401

CORROSION RESISTANCE OF THERMENOL

Acetic Acid (conc)	Excellent
Ferric Chloride (10%)	Not resistant
Ammonium Hydroxide (conc)	Excellent
Hydrochloric Acid (40%)	Fair
Nitric Acid (conc)	Excellent
Nitric Acid (40%)	Fair
Nitric Acid (20%)	Slightly resistant

recording heads. Since the alloy has a low neutron cross section, it has potential use in nuclear reactors.

Metallizing Process

Two or three different kinds of metal, such as lead, copper and steel, can be sprayed at the same time through the same nozzle with new metallizing equipment developed in Russia. According to an article appearing in the Russian machinery journal, *Vestnik Mashinostroyeniya* (Russian), the equipment delivers five different types of deposits that are said to give good antifriction properties to bearings. The deposits consist of 75 steel-25 copper; 75 steel-25 brass; 75 copper-25 lead; 50 steel-50 aluminum; and 50 aluminum-50% lead.

Two Silicones Make Papers Anti-Adhesive

Dow Corning Corp., Midland, Mich., has recently introduced two anti-adhesive silicone treatments for paper and paperboard products. Identified as Dow Corning 22 and 23, the treatments are said to impart to paper and paperboard materials good surface resistance to tacky and sticky materials.

Dow Corning 22 is a water emulsion and Dow Corning 23 is a solvent solution. Both treatments may be applied with conventional equipment to a wide range of paper and paper-like materials, including kraft, parch-

. . . before Northwest developed these SPECIAL ALUMINUM CHEMICALS."

If you work with aluminum you'll be interested in Northwest's outstanding line of chemicals for use with modern alloys. Northwest's continuing research and development program has earned them the reputation of "First with the best" in this rapidly developing field. It will pay you to investigate:

Got a Problem?
Let our Cleaning Specialists help you!

- **ALKALUME CLEANERS—** A full line of cleaners and etching compounds especially formulated for use on aluminum alloys prior to plating, anodizing, painting or welding.
- **ALKALUME PRE-PLATE—** An especially effective zincate bath for preparing aluminum for plating.
- **ACID SOLVENT EMULSION CLEANER No. 1—** An effective cleaner for fabricated aluminum parts before finishing.
- **DRAWING AND STAMPING COMPOUNDS FOR ALUMINUM**

NORTHWEST CHEMICAL PRODUCTS are manufactured on the West Coast by—

ALERT SUPPLY COMPANY
2041 South Davie • Los Angeles 22, California

NORTHWEST CHEMICAL CO.
9310 ROSELAWN DETROIT 4, MICH.

For more information, turn to Reader Service card, circle No. 463

ment, glassine and cellophane. According to Dow Corning, neither treatment affects the appearance, odor, or handling properties of paper stock.

Applications for paper treated with Dow Corning 22 or 23 include boxes, multiwall bags and wrapping paper for raw rubber, asphalt and wax; interleaving sheets for cured-in-place urethane foams, epoxy castings and phenolic laminates; and back-up sheets for labels and pressure sensitive tapes.

Epoxy Tooling Resin Has High Strength

A new epoxy laminating resin with long shelf life is said to have high strength and good dimensional stability. Formulated by Smooth-On Mfg. Co., 572 Communipaw Ave., Jersey City 4, N. J., specifically for laminated plastics tools, the material can also be used as a tank surface coating and as a bonding agent. Called Sonite LM-1, the cured epoxy laminating resin has a tensile strength of 23,000 psi, a flexural strength of 16,000 psi, and an edgewise compressive strength of 25,000 psi.

Laminated Tubing for Press Fitted Parts

A line of small diameter, paper-base phenolic tubing for press-fitted mechanical and electrical assemblies is now available from National Vulcanized Fibre Co., 1057 Beech St., Wilmington 99, Del.

Designated Phenolite Grade XX-3113, the rolled tubing is recommended for use where metal tubes and studs are to be inserted into tubular plastics insulators, as in brush holder assemblies and insulated bushings. The

NEW WAY TO UPGRADE YOUR PRODUCTS: VINYL COATINGS

Leather-like coatings for metal

You'll see a host of profitable ways to use vinyl coatings when you try their pleasant "feel" and test their tremendous durability. Vinyl coatings feel like leather, wear like flooring. They insulate, control corrosion. Are virtually immune to ordinary chemical attack.

You can apply these resilient coatings to your products in a range of thicknesses simply by dipping them in a vinyl dispersion. A short heat-cure at moderate temperatures "sets" the elastomer and permanently bonds it to the metal.

Vinyl coatings can eliminate some steps in finishing operation, actually reduce total costs. Coatings can range from soft and rubbery to "tire-casing" hard—in any color you choose.

Write for sources of vinyl in liquid form for coating glass, metal, or wood. Get a head start on investigating the many new, market-building ways you can use vinyl dispersions. Write today!

Monsanto manufactures a wide variety of plasticizers and Opalon® resins for formulators of these high-quality vinyl dispersions.

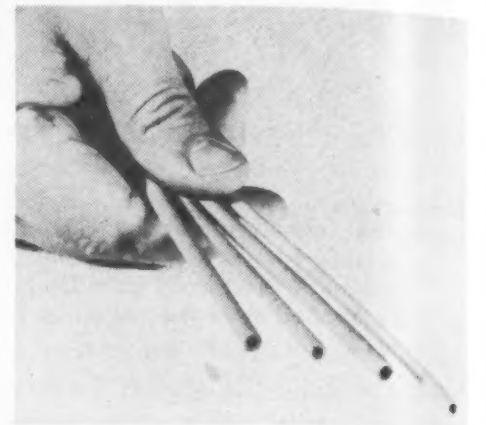
MONSANTO

Where Creative Chemistry Works Wonders for You

Organic Chemicals Division
MONSANTO CHEMICAL COMPANY
Dept. SP-4, St. Louis 1, Missouri

For more information, turn to Reader Service card, circle No. 429

What's new IN MATERIALS



Small tubing *for press-fitted mechanical and electrical assemblies.*

material has a density of 1.20 to 1.25 and an axial compression strength of 17,100 psi. It is available in sizes ranging from 0.093 to 0.379 in. i.d., in wall thicknesses from 0.010 to 5/64 in., and in lengths up to 25 in.

Aluminum Powders Made into Sheets, Foil

Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa., has announced the availability of three aluminum powder metallurgy products. One of the aluminum products, designated Alloy M 257, is said to raise the useful temperature range of aluminum alloys by about 300 F. (For more information on aluminum powder metallurgy products, see MATERIALS & METHODS, Apr '56, p 106.)

The three alloys are Alloy M 257, made of domestic aluminum powders, and Alloys M 430 and M 470, made of aluminum powders imported from Switzerland. The aluminum powder metallurgy products are available in the form of extruded shapes, forgings, sheet, foil, drawn and extruded tube, impact extrusions, fasteners and wire.

According to Alcoa, the alloys are being evaluated for use in honeycomb sandwich structures and heat exchangers.

(more What's New on p 198)

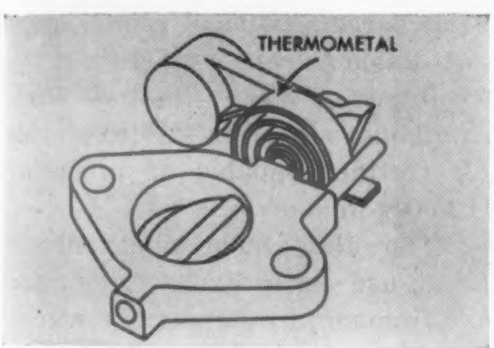
No. 4
of a series of ads dealing with basic facts about thermostatic metals.

Designing for Product Improvement With WILCO THERMOMETAL®

Thermometal in Temperature Compensation

Many devices and instruments are affected by ambient temperature changes which results in inaccuracy or inefficient operation. Since Thermometal can transform temperature changes into mechanical motion it can be used to compensate these products for practically any function which is sensitive to temperature change and improve their performance.

Typical examples are. In the modern automotive carburetor, a Thermometal helix automatically closes the choke valve with decrease in temperature thereby increasing the fuel-air ratio for a faster start on cold days. As the engine warms up the choke opens again reducing the fuel-air ratio. And a Thermometal coil also actuates the automatic manifold heat control which bypasses hot exhaust gas around the intake manifold until the engine is fully warmed, then directs it back into the muffler.

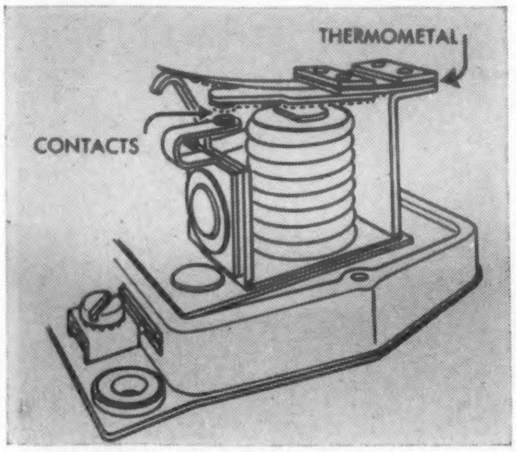


Even the voltage regulator air gap is varied by a Thermometal hinge or cantilever blade in order to obtain best ambient temperature performance.

Thermometal temperature compensating elements are also used in electrical appliances, aircraft instruments, timing relays, circuit breakers, and a great variety of electrical devices.

Thermometal is ideally suited for temperature compensation because:

1. It can be used to transform temperature change into motion or pressure

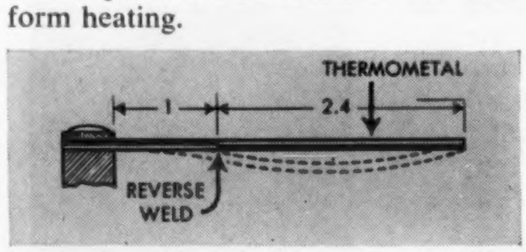


without complicated linkages or fluid systems, such as diaphragms or bellows.

2. The use of a Thermometal spiral or helix is the simplest and most economical method to transform temperature changes into a rotary motion without the use of gears or other complicated mechanical systems.

3. Thermometal is the most economical method for providing a small motion required to compensate for ambient temperature effects of other temperature-sensitive devices, such as bulb and bellows thermostats, thermocouple cold junctions, electrical appliances, etc.

4. By specific design and choice of one or more Thermometals, it is possible to obtain an inherently temperature-compensated element which will not respond to ambient temperature changes, but will respond to differential or non uniform heating.



Thermometal is a unique temperature-compensating element because it can be rolled into any thickness and formed into almost any shape as required. It is used in the form of cantilever blades, U-shapes, spirals and helices, in almost any mechanical size and configuration, as required to provide specific temperature compensation. It is the most economical method of obtaining ambient temperature compensation, and is singularly free from the limitations of other temperature compensators.

Factors Governing Selection

1. Temperature range over which compensation is required.

2. Maximum and minimum temperature encountered in service.

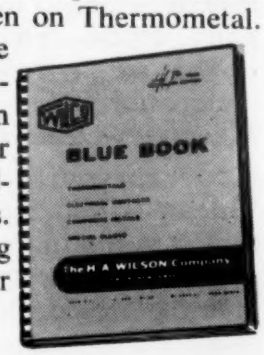
3. The amount of movement or force required to effect compensation.

4. Electrical and thermal conductivity required for the application.

5. Space limitations which govern shape required.

The H. A. Wilson Company, American pioneer in the development and manufacture of thermostatic metals, produces over 40 varieties of Thermometal, as well as a complete line of electrical contacts. In many temperature control units both Thermometal and electrical contacts are used. We make a specialty of supplying complete sub-assemblies for these devices, including mounting brackets, pigtails, and other current-carrying members.

Reprints of this series are available on request. For further information about our products, ask for the Wilco Blue Book, the most complete reference manual ever written on Thermometal. And if you have any immediate application problem for Thermometal or other Wilco products, please tell us. Our engineering service is at your disposal.



WILCO®

THERMOMETALS
ELECTRICAL CONTACTS
COMPOSITE METALS
SPECIAL PURPOSE ALLOYS

THE H. A. WILSON COMPANY
2655 U. S. Route 22, Union, N. J.
Branch Offices: Chicago • Detroit • Los Angeles • Providence

ENGELHARD INDUSTRIES

For more information, turn to Reader Service card, circle No. 583

What's new IN MATERIALS

Pure Silicon Has High Voltage Capacity

Extremely pure silicon, said to permit large volume production of electronic devices having two to four times the voltage and power handling capacities of devices presently in use, is commercially available from Westinghouse Electric Corp., Pittsburgh, Pa. The impurities in this material, Westinghouse says, are less than one part in six billion.

According to the producer, single crystal properties of the new silicon range from 400 to 1000 ohm-cm resistivity with a lifetime of 400 to 800 microseconds. These properties are claimed to be better than properties of most commercially available silicons by a factor of five. Compared with commercially available silicon rectifiers with top voltages of 600 v, the new Westinghouse silicon is said to provide a rectifier capable of producing 1000 v or more.

The ultra pure silicon should find use in radio and television equipment; in industrial controls; and in automobiles for a.c., ignition and fuel control systems.

The material is the result of a new silicon making process developed by Siemens & Halske and Siemens-Schuchert in Germany. The work of these two companies was supplemented by certain research contributions made by Westinghouse.

Evaluating Tests for Plastics Assemblies

If design engineers are to accept plastics as engineering materials, the mechanical properties of these materials must be known not only under normal conditions of use but also under unusual environmental conditions. This is the opinion of R. A. McCarthy, Mon-

santo Chemical Co., who spoke on the development of performance tests for finished plastics goods at the 1957 Technical Conference of the Society of Plastics Engineers.

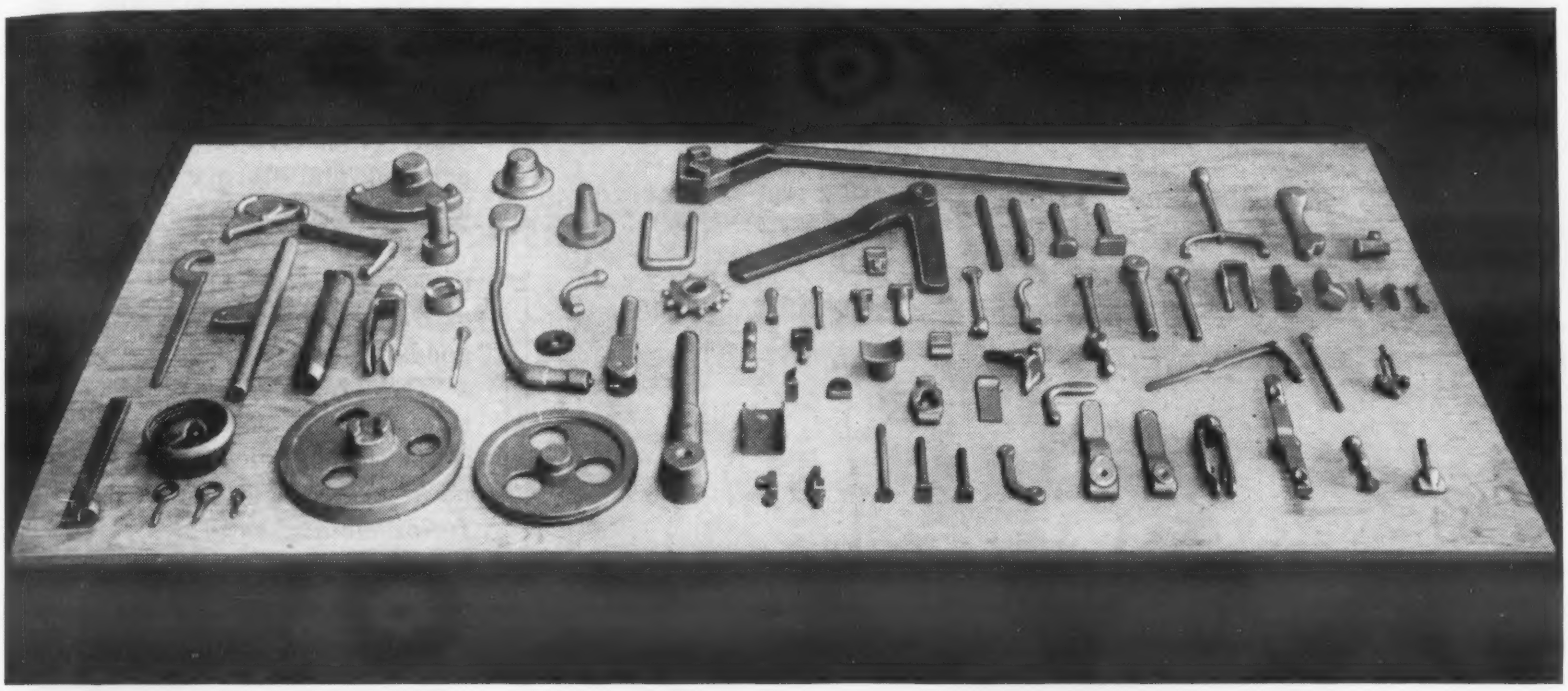
Mr. McCarthy points out that designers of plastics products must rely on mechanical property values taken from testing finished plastics parts. He says these values are unreliable for two reasons: 1) finished plastics goods do not lend themselves to conventional ASTM testing methods, and 2) the wide variety of plastics shapes available necessitates the use of extremely versatile testing methods.

Compared with other materials, plastics act differently when they are assembled into a part. The mechanical properties of molded plastics parts are greatly affected by such fabricating techniques as welding, nailing and bolting. On the other hand, the mechanical properties of a steel or a wooden beam remain relatively constant when introduced as a component in an assembly.

Drop tests

There are only a few tests generally used to evaluate finished plastics products. One is a drop test used to simulate breakage of plastics parts in shipment and use. To meet the need for better tests, research groups are experimenting with a wide variety of tests. Mr. McCarthy says that the most successful work at Monsanto has been with ball drop and dart drop tests.

The ball drop test consists of dropping a steel ball from varying heights on plastics goods. The end point is reached when visible cracks appear in the plastics part. This test is a usable tool for estimating impact resistance of plastics door liners, radio cabinets and containers. Stress values resulting from the test are approximately the same as values obtained from Izod impact tests on



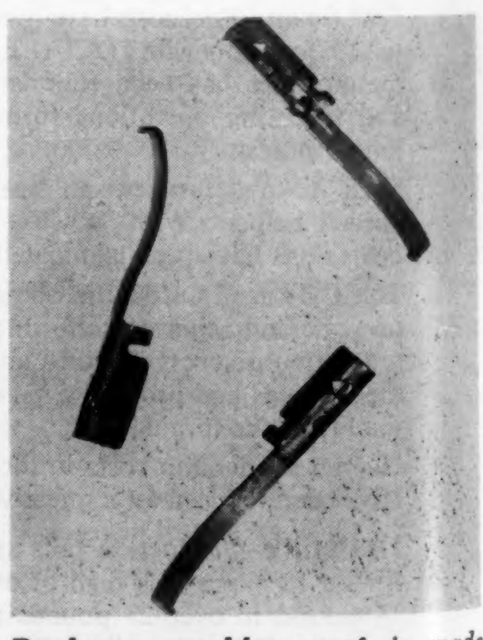
plastics products. The major advantage of the test is that the direction of fracture is not controlled as it is in Izod impact tests. At present, efforts are being made to correlate ball drop test values with ASTM impact test values.

The dart drop test, used to evaluate the toughness of polyethylene films, is essentially the same as the ball drop test except that a dart is used instead of a steel ball. This test is used to study the effects of handling, printing and storage on polyethylene film.

Mr. McCarthy concludes that design engineers should make use of values obtained from finished goods testing in order to develop a "feel" for plastics. He cautions that designers should never design a plastics product with the viewpoint that plastics act like inferior metals.

Plated Metal Strip Has Uniform Finish

A new plated metal strip is being used as a substitute material for pure nickel in the fabrication of electronic parts that are to be



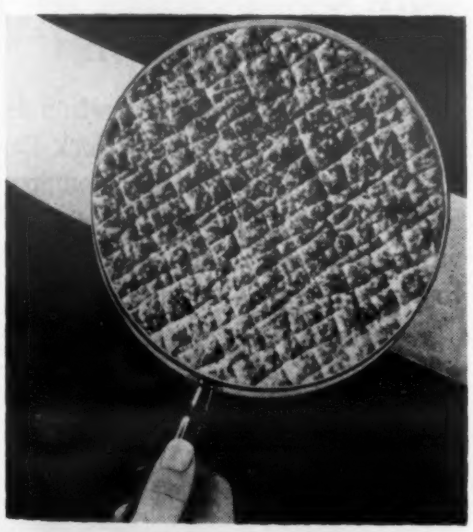
***Business machine part** is made of Sylvania's plated metal strip.*

For more information, circle No. 612 ➤

What's new IN MATERIALS

exposed to high temperatures. The plated strip is the result of a new concept in metal strip plating developed by Sylvania Electric Products, Inc., 12 Second Ave., Warren, Pa. According to Sylvania, carbon and stainless steels, brass, bronze, copper and nickel can be plated with such commonly used plating materials as nickel, silver, copper and tin.

One of the outstanding features claimed for the new process is the high degree of uniformity of specified plating thickness from side to side. The company claims that the plating thickness will not vary more than ± 2% on both sides of the strip. In addition, edge-to-edge uniformity of plating thickness will not vary more than ± 3% on each side. However, because of the high current density characteristics encountered at the edges of a strip during any plating operation, plating is heavy along the edges regardless



Gummed paper tape—Shown above are magnified glue fractures formed in a new gummed paper tape developed by Crown Zellerbach Corp., 343 Sansome St., San Francisco 19, Calif. The tape has a glue film that is diagonally broken to form thousands of microscopic channels to speed water flow and make the tape more pliable. According to the producer, the tape does not curl and can be molded like wet cloth.

of the process; therefore when a 10-in. wide plated strip is produced, only the center 9½ in. surface can be expected to hold a plating tolerance of ± 3% on any one side.

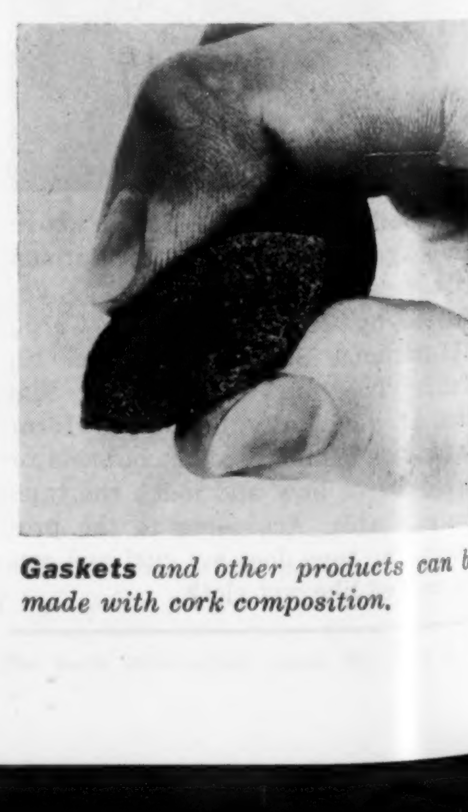
Applications

The plated metal strip is recommended for use in business machines and in electrical and electronic devices. In addition, the company says that the plated strip can eliminate the need for plating formed metal parts. This should permit the use of assembly techniques that were previously impossible because of the need for plating formed parts after fabrication.

The metal strip, usually supplied in widths from ½ to 3 in., can be produced with a plating thickness as high as 0.005 in. per side. Also, the strip can be obtained with a 0.002 in. thick coating on one side and a 0.001 in. thick coating on the other side.

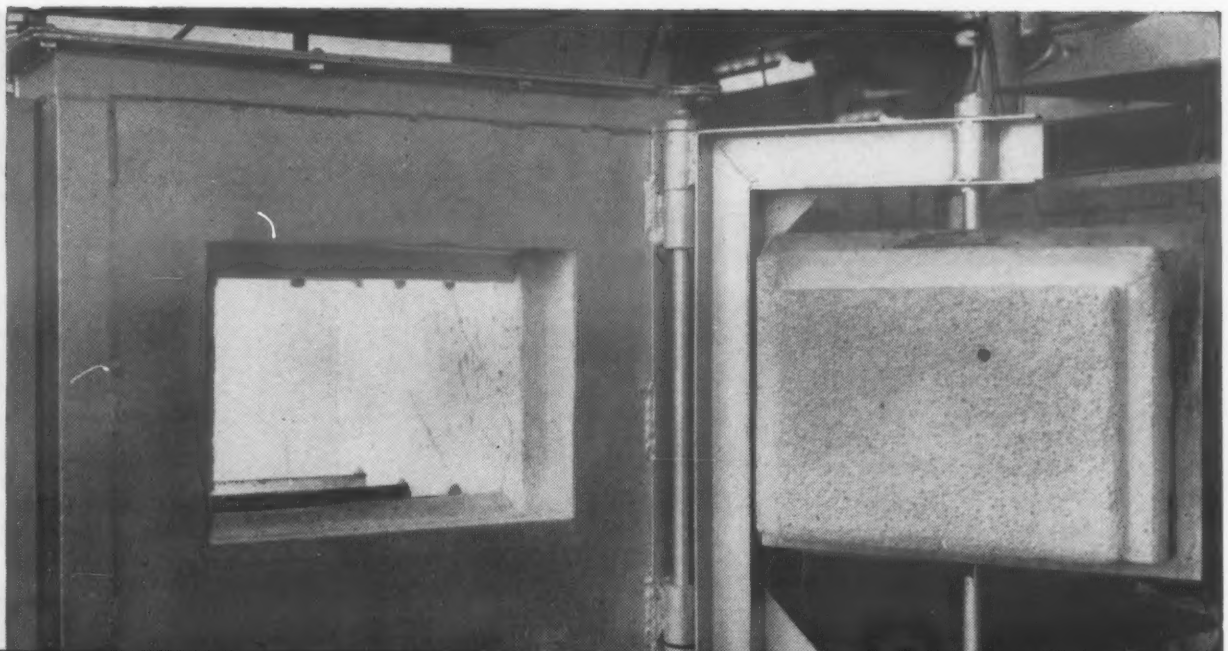
Cork Composition Has Good Compression

A flexible cork composition developed by Armstrong Cork Co., Lancaster, Pa., is said to compress as much as needed to support various weight loads and return to its original state smoothly and

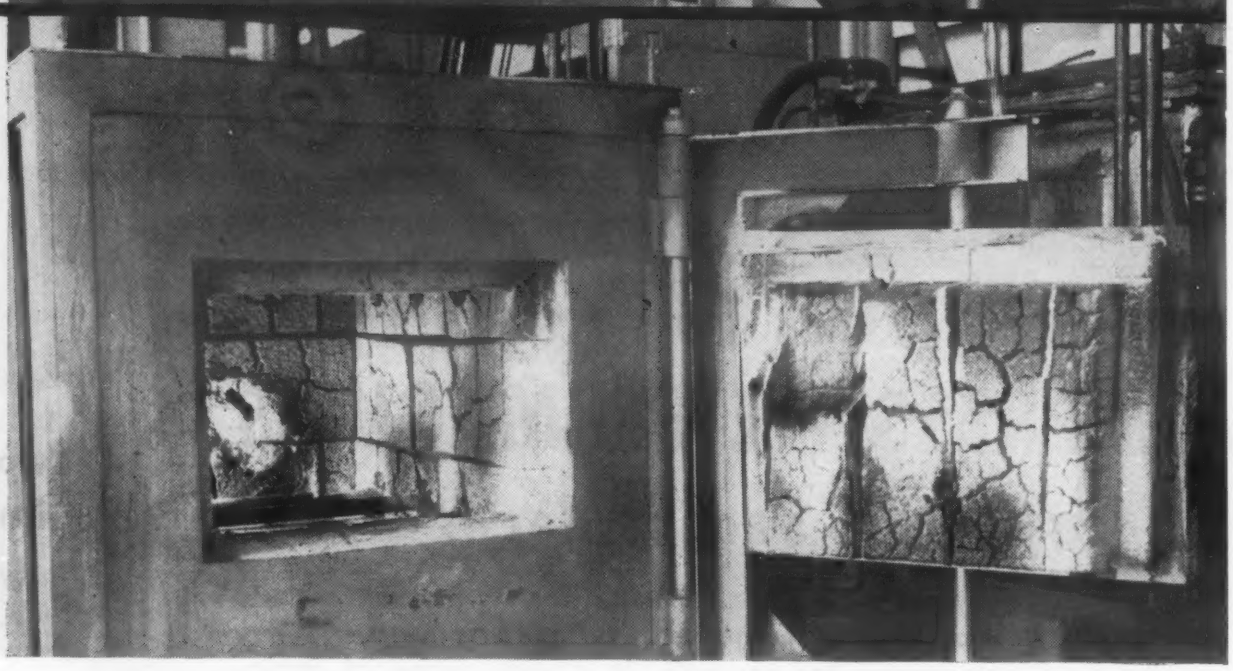


Gaskets *and other products can be made with cork composition.*

LINED WITH ALUNDUM 33-I CASTABLE, this furnace has been used for almost a year as a periodic furnace for high-temperature laboratory test work. During this time the door was opened and closed over a thousand times with the furnace at temperature. Even after this rugged service, the ALUNDUM Castable lining shows hardly any signs of wear.



LINED WITH A COMPETITIVE HIGH GRADE INSULATING BRICK, this similar furnace was used in the same service for an equal length of time. Under equally severe thermal shock conditions the lining cracked and spalled and this furnace must be rebuilt.



You get higher temperature protection with ALUNDUM* castables

Up to 3300° F!

ALUNDUM 33-I Insulating Castable is made up primarily of countless tiny, pure aluminum oxide bubbles. Forming a network of air spaces it provides excellent insulation, even at the highest commercial temperatures.

ALUNDUM 33-HD Heavy Duty Castable is chiefly composed of dense grains of pure aluminum oxide. It is recommended for forming dense monolithic surfaces in constructing many types of furnaces where high temperature conditions are more severe.

Both ALUNDUM 33-I and 33-HD Castables protect at temperatures up to 3300° F and are very easy to mix and use. You can cast simple or complex shapes with them quickly and inexpensively for many installations and replace more expensive pre-fired shapes.

See your Norton Representative for more facts on how these new Castables can provide long, trouble-free service that saves you time and money. Ask him for the folder *Two New Norton Castables*, or write for your free copy to NORTON COMPANY, Refractories Division, 351 New Bond Street, Worcester 6, Mass.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

NORTON
REFRACTORIES
Engineered ... R ... Prescribed
Making better products ... to make your products better

NORTON PRODUCTS:
Refractories • Abrasives
Grinding Wheels • Grinding Machines
BEHR-MANNING DIVISION PRODUCTS:
Coated Abrasives • Sharpening Stones
Behr-cat Tapes

For more information, turn to Reader Service card, circle No. 370

PROPERTIES OF CUSHION CORK

Tensile Strength, psi	70
Elongation, %	30
Min Indentation (100 psi), %	60
Min Recovery, %	85
Compressive Modulus, psi	
20%	20
60%	50
Density	13.0

evenly. The material is made with a new process that binds minute cork particles together with a synthetic resin binder under heat and pressure.

Developed for use in gaskets the cork composition is said to have good resistance to water, mold growth, heat, cold and chemicals.

Two Corrosion Tests Simulate Service Life

Two accelerated corrosion tests for decorative plated coatings seem to overcome most of the faults associated with the standard salt spray test. The tests, an acetic acid modified salt spray test and the Corrodkote test, are the result of a research project sponsored by the American Electroplaters' Society. (For more information on accelerated corrosion tests, see MATERIALS & METHODS, Nov '53, p 110.)

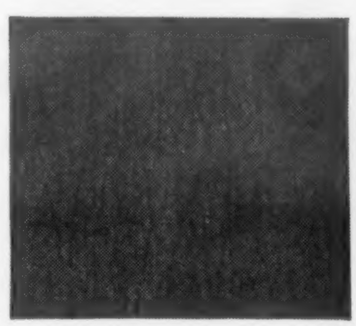
The Society's research project covered the following areas: 1) design and fabrication of test specimens; 2) study of environmental conditions that cause corrosion of the test specimens; 3) study of 25 different types of corrosion; 4) selection and refinement of accelerated test procedures; 5) specification detailing exact accelerated test procedure; and 6) calibration of test results to comply with industry specifications.

Details of the two test procedures, written by W. L. Pinner, Houdaille Industries, Inc., were presented by R. B. Saltonstall,

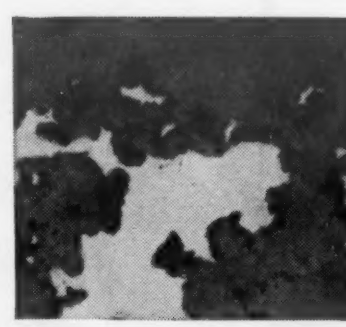
Creative papers from the mills of Mosinee

And now . . . paper that finally defies mold

Only Mosinee — with its specialized research and manufacturing facilities — could bring you a paper with lasting, built-in resistance to fungus growth. NeverMold — *the paper that finally defies mold* — is ideal for scores of uses — packaging, structural fabrication, insulation, wherever protection against mildew or rot is desired. It's especially valuable for products that are shipped or stored in humid or tropical climates or for applications dealing with direct soil contact. Remember the name — NeverMold — one of many creative papers developed and perfected by the mills of Mosinee.



NeverMold paper—Unaffected after *four-week* soil burial test.



Untreated paper—Subjected to same test, disintegrated within *one week.*

FIND OUT how NeverMold paper can serve you. Fill out and mail this coupon.

Mosinee
PAPER MILLS COMPANY
MOSINEE, WISCONSIN

MOSINEE PAPER MILLS CO., Dept. MM-10, Mosinee, Wis.
Please send complete information file on NeverMold paper.

Name and Title..

Firm Name..

Address..

City.............................Zone.........State....................

For more information, turn to Reader Service card, circle No. 407

What's new IN MATERIALS

Udylite Corp., at the SAE Summer Meeting held in Atlantic City.

Modified salt spray

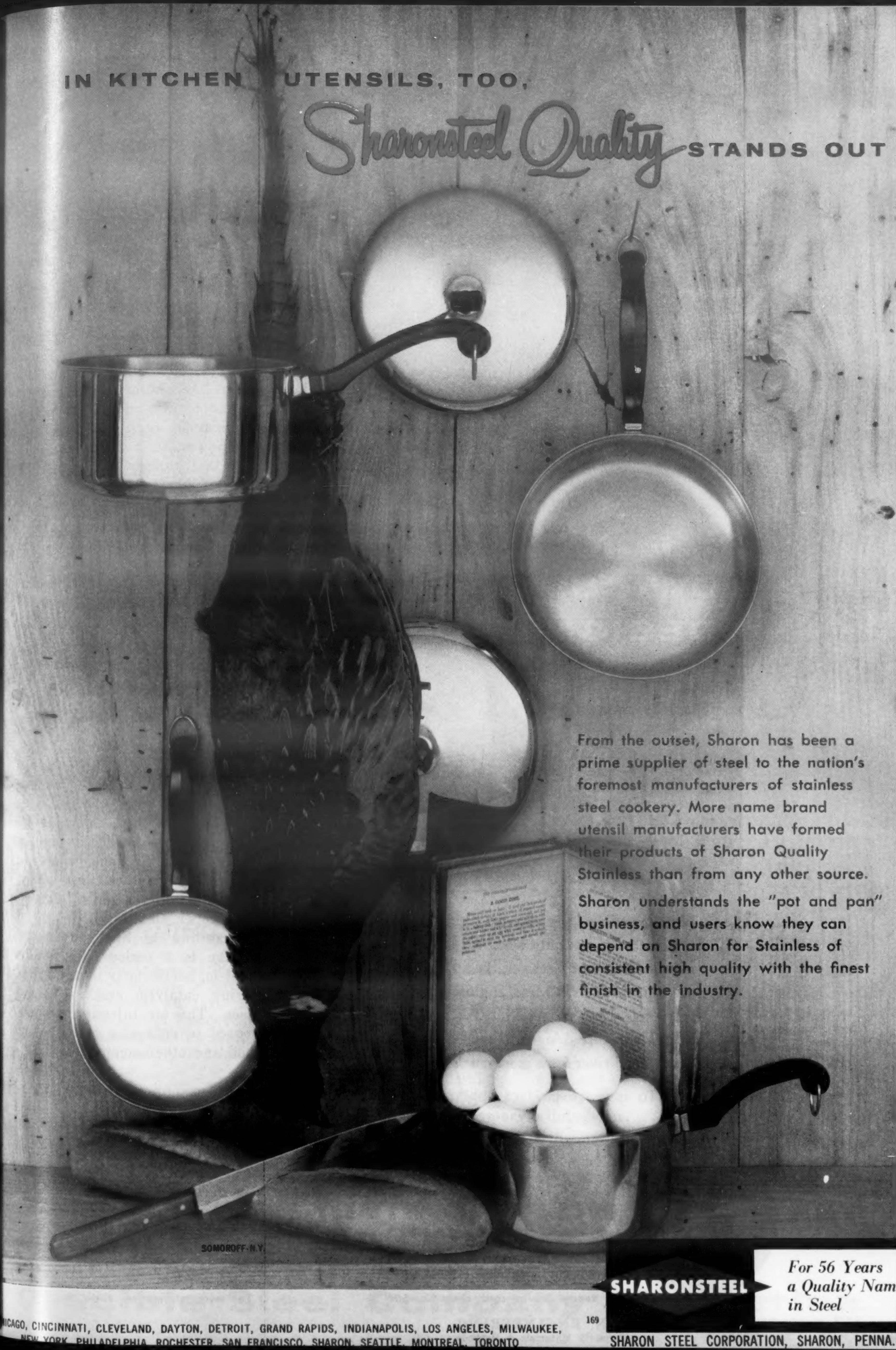
The acetic acid modification of the salt spray test is somewhat similar to the standard salt spray test, the difference being that the standard salt spray solution contains acetic acid. According to Mr. Saltonstall, the addition of acetic acid to the salt spray solution results in a good reproduction of the types of corrosion that occur on copper-nickel-chromium plated parts in service. The neutral salt spray test failed to do this in many instances. Other modifications of the standard salt spray test, of equal or even greater importance than the chemical composition of the salt solution, are: type of equipment; method of conducting the test; statistical methods of sampling; and statistical analysis of test results.

Corrodkote test

Mr. Saltonstall explains that the Corrodkote test is actually a controlled adaptation of environmental conditions to which exterior plated parts are exposed in service. An example would be plated automobile parts that become coated with road slush while exposed to acids and other contaminants present in the air. The plated parts, still covered with salt and acid-bearing slush, are stored in the presence of high humidity. Such a condition has been known to result in the rapid deterioration of decorative plated parts. This condition of slush and contaminated air is especially prevalent in northern industrial cities where large amounts of salt are used for melting ice and snow off the city streets.

Basically, the corrosion test is a method in which plated surfaces are made wettable by rubbing them with an abrasive compound that contains certain specific

For more information, circle No. 523 ➤


IN KITCHEN UTENSILS, TOO,
Sharonsteel Quality STANDS OUT
From the outset, Sharon has been a prime supplier of steel to the nation's foremost manufacturers of stainless steel cookery. More name brand utensil manufacturers have formed their products of Sharon Quality Stainless than from any other source.
Sharon understands the "pot and pan" business, and users know they can depend on Sharon for Stainless of consistent high quality with the finest finish in the industry.
SOMOROFF-N.Y.
SHARONSTEEL
For 56 Years a Quality Name in Steel
SHARON STEEL CORPORATION, SHARON, PENNA.
CHICAGO, CINCINNATI, CLEVELAND, DAYTON, DETROIT, GRAND RAPIDS, INDIANAPOLIS, LOS ANGELES, MILWAUKEE, NEW YORK, PHILADELPHIA, ROCHESTER, SAN FRANCISCO, SHARON, SEATTLE, MONTREAL, TORONTO

chemicals in the form of a paste. The paste-coated part is then subjected to high humidity under controlled conditions resulting in an accelerated attack on the plated part.

The abrasive paste is made up of kaolin, cupric nitrate, ferric chloride, ammonium chloride and water. According to the author, the use of this mixture on plated parts under high humidity conditions results in a type of corrosion that exactly duplicates the type of corrosion occurring on plated parts in Detroit during the winter.

Mr. Saltonstall says that it is still necessary to correlate test values obtained from both procedures with plating industry specifications.

New Process Checks Blistering of Steel

A process to prevent hydrogen blistering of steel refinery equipment has been developed by Shell Development Co., 50 West 50th St., New York City. Company officials say the patented process works by injecting small amounts of air into steel refinery equipment. Ammonia is added to maintain proper alkalinity.

According to Shell, hydrogen damage is a serious and costly problem, particularly in units processing catalytic cracking plant gases. The air injection process is used in refineries operated by Shell and other companies.

Nonmagnetic Metal

A special, nonmagnetic thermostat metal called Truflex S125 has been developed by Metals and Controls Corp., General Plate Div., Attleboro, Mass., for use in electrical instruments. According to the producer, magnetic forces up

For more information, circle No. 448 ➤

Navy A3D, largest carrier based jet aircraft

The hook's made of Hy-Tuf

designed to take exactly this kind of beating

In a split second, an arresting hook made of Crucible Hy-Tuf® stops a jet dead in its tracks. No other alloy can meet this particular aircraft's needs so well. And Hy-Tuf does it because it was developed by Crucible specifically for aircraft landing gear, hooks, and other such tough applications. Hy-Tuf is covered by AMS-6418B and MILS-7108.

Now other fields are benefiting from Hy-Tuf's tensile strength of over 230,000 psi. By taking advantage of its high strength and high toughness, cross section can be reduced to save weight. This means savings on a variety of applications from heavy-earth-moving equipment to power tools . . . power-driven garden tools . . . and all types of portable motors where a high strength-weight ratio is important.

Furthermore, special *tools* and *shafts* are logical applications for Hy-Tuf when weight and cross-sectional dimensions must be limited. Where such limitations do not permit sufficient fillet or radius for standard alloys, a higher impact and less notch sensitive alloy, such as Hy-Tuf, is needed.

Ask for data about Hy-Tuf or other ultra high strength steels which may meet your needs more closely.

Write to Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

to 250 oersteds fail to move the material; regular thermostat metal elements are said to be greatly influenced by magnetic fields that exist in electrical instruments. The company claims that with use of Truflex S125 thermostat metal the influence of magnetic fields can be eliminated in electrical instruments.

New Developments in Ceramic Materials

Roller bearings, pistons and cylinders, seals, electrical insulation, acid pump plungers, core materials and aircraft radomes are but a few of the many new and interesting areas where ceramic materials are being used.

The properties of some ceramic materials, especially inflexibility, extreme abrasion resistance and high strength, make the use of ceramic tools ideal for high speed machining of metals to close dimensional tolerances. Actual case histories show reductions in machining costs ranging from 50 to 80%.

Reviewing technical developments in the field of ceramic and refractory materials at the 1957 Design Engineering Conference, John H. Koenig, director, and Edward J. Smoke, professor, School of Ceramics, Rutgers University, pointed out that a great deal of progress has been made in developing new and better ceramic materials, refractories and refractory coatings, cermets and glasses for a number of military, industrial and commercial applications. The conference, which ran concurrently with the Design Engineering Show, was sponsored by the American Society of Mechanical Engineers.

Ceramic developments

Roller bearings—Much progress has been made in developing ceramics for use in the tool, aircraft,

Save Time, Maintenance and Money In Your Metal-Melting . . .

Specify Norton Refractory Cements

FOR FERROUS METAL-MELTING

type of equipment	metals melted	use of cement	Norton cement recommended			how applied
			number	maturing temperature		
indirect arc	alloy iron and steels	lining	RA 1307	1150°C	2100°F	rammed
		patching	RA 1307 RA 1162	1150°C 1000°C	2100°F 1850°F	rammed rammed
direct arc	alloy steel and malleable iron	troweling around electrodes	RA 1162	1000°C	1850°F	trowled
		lining roof and around electrodes	RA 1307	1150°C	2100°F	rammed
high frequency induction	stainless steel and refractory alloys	lining	RM 1170	1150°C	2100°F	rammed (dry)
		patching large furnaces	RM 1152	1200°C	2200°F	rammed
		patching small furnaces	RM 1992	1100°C	2000°F	troweled or rammed
ladles	iron and steel	lining	RA 1307	1150°C	2100°F	rammed

FOR NONFERROUS METAL-MELTING

low frequency induction	Al, Te, Si bronzes	lining	RM 1140	1250°C	2300°F	rammed
	general purposes	lining	RA 1307	1150°C	2100°F	rammed
indirect arc	brasses and bronzes	lining and patching	RA 1307	1150°C	2100°F	rammed
crucible melting furnaces ■	brasses and bronzes	lining and patching	RC 1188	1100°C	2000°F	rammed
reverberatory furnaces ▲	brasses and bronzes	lining and patching	RC 1188	1100°C	2000°F	rammed

■ Cement not in contact with metal; used in combustion chamber. ▲ Cement in contact with metal.

Norton ALUNDUM* fused alumina (RA), CRYSTOLON* silicon carbide (RC) and MAGNORITE* fused magnesia (RM) cements are stable and very refractory. Carefully blended to assure proper grain size distribution, they are excellent for the widest range of operations.

For complete facts as to the nature and selection of these *engineered and prescribed* Norton ℞'s, contact your Norton Representative. He'll supply you with the booklet *Norton Refractory Cements.* Or write for your free copy to NORTON COMPANY, Refractories Division, 350 New Bond Street, Worcester 6, Mass.

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

NORTON

REFRACTORIES

Engineered . . . ℞ . . . Prescribed

Making better products . . . to make your products better

NORTON PRODUCTS: Refractories • Abrasives
Grinding Wheels • Grinding Machines
BEHR-MANNING DIVISION PRODUCTS: Coated Abrasives
Sharpening Stones • Behr-cat Tapes

For more information, turn to Reader Service card, circle No. 451

electrical and electronic industries. For instance, complete roller bearing assemblies, including rollers and racers, have been made of high alumina ceramic materials. The bearings can be machined to very close dimensional tolerances. Also, they require no lubrication, since the coefficient of friction of alumina on alumina is very low. Another use for alumina ceramics is in pumps for handling abrasive and corrosive materials.

Permanent magnets—A new, high energy type, permanent ceramic magnet that is 3½ times stronger than conventional ceramic magnets has been developed. The authors also mentioned the development of a soft ceramic magnet that can be used to 1000 mc; conventional ceramic magnets of this type can be used only to 100 mc.

Sandwich constructions—Several types of ceramic honeycomb sandwich construction that can withstand temperatures up to 3000 F have been developed. These constructions have compressive strength values as high as 30,000 psi. Another sandwich construction, reportedly used in a new high speed jet, uses fiberglass as a honeycomb material between two layers of metal. This construction is said to have excellent resistance to buckling under high temperatures and pressures.

Glass developments

Koenig and Smoke outlined a number of new and improved matrials, processes and treatments that are currently being evaluated in the glass industry. Some of the new and improved glass products the authors discussed were photosensitive and devitrified glass; glass fibers; glass dispersions; optical glass; and glass flakes.

Fiber insulation—Glass fibers are finding increased use as insulation for household appliances, air conditioners, pipes and noise control products. They are also be-

Expand your lines...with GREX*

The many desirable properties of GREX make possible countless new applications and product improvements. Now you can better keep pace with the ever growing market for high quality plastics and show steadily rising sales and profit curves.

GREX is a high density polyethylene with superior impact and tensile strength. It has exceptionally high heat distortion temperature . . . won't buckle when sterilized. And you can freeze it with no danger of brittleness. GREX resists acids . . . virtually stops moisture vapor transmission . . . makes efficient electrical insulation. GREX takes and holds intricate shapes and fine detail and produces a colorful, high-gloss brilliance that lasts.

Plan a new line? Wish to upgrade a present line? Want to diversify? Investigate GREX! For full details, complete and mail the coupon.

*TRADEMARK FOR W. R. GRACE & CO.'S POLYOLEFINS

W. R. GRACE & CO.
POLYMER CHEMICALS
DIVISION

Plant
Baton Rouge, La.

W.R. GRACE & CO.

Offices
Clifton, N. J.

W. R. GRACE & CO., POLYMER CHEMICALS DIVISION,
Dept. MDE 1057, 225 Allwood Road, Clifton, New Jersey

Please send more information about GREX high density polyethylene. I am interested in these uses: ....

....

NAME................................TITLE...............

COMPANY..

ADDRESS..

CITY................................STATE..............

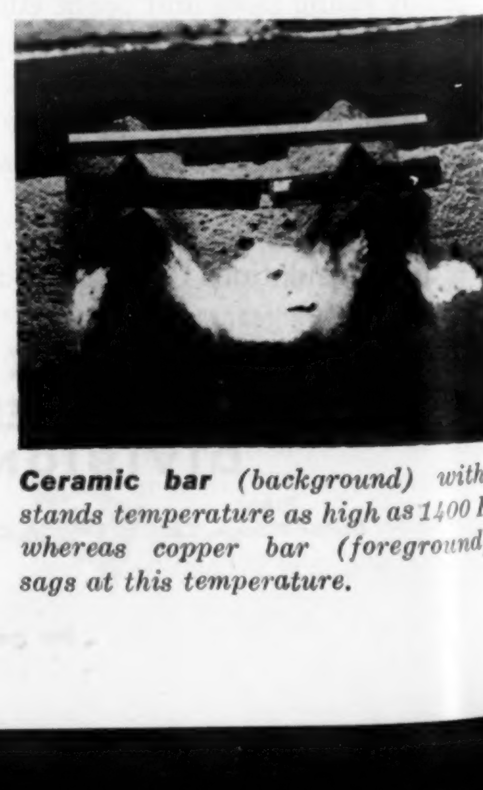
For more information, turn to Reader Service card, circle No. 514

ing considered as additives for paper. It seems that the addition of relatively small amounts of glass fiber to pulp improves dimensional stability of the paper without detracting from other physical properties. Glass fiber additives also make paper faster drying and reduce its machine width shrinkage. Optical glass fibers are being tested as dosimeters for use in cancer research.

Flake reinforcement — Plastics laminates made with glass flakes and epoxy resins have flexural strengths as high as 55,000 psi. Electrical grade plastics molding compounds show considerable increase in dielectric fatigue resistance when glass flakes are used as a filler. Glass flake-reinforced polyethylene has good cut resistance and less tendency toward stress cracking than reinforced polyethlyene. Papers made with high percentages of glass flakes have excellent dielectric strength prior to impregnation. (For more information on glass flake reinforcing agents see MATERIALS IN DESIGN ENGINEERING, Aug '57, p. 160.)

Refractory developments

Furnace liners—A new melt cast refractory product that has good corrosion and heat resistance is made by electrically melting magnesite and chromium ore at a



Ceramic bar *(background) withstands temperature as high as 1400 F whereas copper bar (foreground) sags at this temperature.*

temperature of 4300 F. The molten refractory is then poured into molds of shape and size suitable for later use in lining furnaces. According to the authors, the new refractory should give steel operators greater productivity per furnace and lower furnace maintenance costs.

High temperature castable refractories are also being used as roofs for electric arc furnaces. According to the authors, there is now commercially available a castable refractory that withstands temperatures of 3200 F, resulting in better operating efficiency.

Firebrick—There has been increasing use of insulating firebrick in the construction of kilns. Such kilns are periodically heated and cooled, and the light weight and low heat storage of insulating firebrick reduces the amount of heat absorbed by the kiln during firing. Savings of 15 to 30% in fuel consumption have been reported.

Another high temperature refractory is made of fused alumina bubbles. To demonstrate the effectiveness of this type refractory as a heat insulator, a conventional size brick made of the material was cemented to a ¼-in. steel plate and heated with an acetylene torch. A person's hand was held to the brick while the torch was being applied. Although the steel plate melted, there was no discomfort to the person holding the brick. This type material is supplied as a castable by several companies and can be formed into the desired shape on the job.

Abrasion resistance and stability of phosphate type refractories is greatly increased when chemical binders are added to the mix. These materials are showing particular promise for use as linings in furnaces operating at temperatures up to 2000 F.

Cermet developments

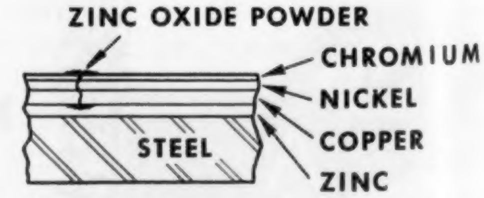
A new cermet produced from silicon carbide and molybdenum

has high strength at high temperatures. Transverse strength of this material is 42,200 psi at room temperature and increases to 71,900 psi at 1800 F. For jet engine applications a cermet based on chromium-molybdenum boride that can be used up to 1800 F has better oxidation resistance and hot strength than titanium carbide.

Zinc Base Plate Stops Chromium Plate Peel

Chromium plated steel parts, plated with a new technique, do not rust, blister, crack or peel after exposure to 20% salt spray for 192 hr at 212 F. The new chromium plating process was developed at Wagner Bros., Inc., Detroit, Mich. According to Bruno Leonelli, developer of the technique, the process involves the use of a zinc base plate in a copper-nickel-chromium plating sequence. The zinc base plate gives galvanic protection to the steel part, preventing cracking and peeling of the chromium electroplate.

Mr. Leonelli explains that the zinc base plate principle has been common knowledge throughout the plating industry for many years but had never before been successfully applied to a copper-nickel-chromium sequence because of the affinity between zinc and copper. This affinity, he says, results in a molecular "blending" of the zinc and copper layers that creates a gap between the surface of the part and the plating metals. The gap, Leonelli says, inevitably re-



***Zinc base plate** oxidizes more easily than steel, forming harmless zinc oxide powder that can be wiped from the plated surface with a rag.*

sults in the rapid cracking and peeling of the plated surface. The new method, still in the development stage, apparently overcomes this drawback.

The process should find use in plating such items as automotive trim and household appliances.

Colored Teflon Tapes Are Used for Coding

Teflon tapes, ranging in thickness from 0.001 to 0.125 in., are now available in a number of colors for coding and identification purposes. According to the producer, Polymer Corp. of Pa., 2140 Fairmont Ave., Reading, Pa., the tapes meet NEMA requirements and certain military specifications.

Known commercially as Polypenco Teflon tapes, the colored tapes are said to retain basic Teflon tape properties. They have a dielectric constant of 2.0, a volume resistivity of 10^{18} ohm-cm, and dielectric strengths of 6000 v per mil on 1-mil tape, 2500 v per mil on 5-mil tape and 600 v per mil on 125-mil tape. According to the producer, the tapes are usable over a temperature range of -320 to 500 F.

The colored tapes may be used for such applications as wire wrapping of hook-up and thermocouple wires and coaxial cables. They may also be used for chemical packings, gaskets and liners.

Two Plastisols Used in Rotational Molding

Two plastisol formulations, developed by the Goodyear Tire and Rubber Co., Chemical Div., Akron 16, Ohio, are expected to find extensive use for rotational moldings.

The formulations are based on Pliovic AO, a vinyl dispersion resin, and Pliovic S70, a medium viscosity resin. According to the

For more information, turn to Reader Service card, circle No. 538

producer, color, gloss and hardness properties of the finished product may be varied by changing the formulations slightly.

The plastisols are recommended for such rotational molded items as doll parts, desk equipment, hunting accessories and assorted specialty items. Rotational molding is said to permit accurate weight control of molded products, reduce plastisol contamination and provide a clean operation.

Glass Fiber Mats

A line of decorative glass fiber mats is available in a number of new patterns and colors from Famco, Inc., P.O. Box 35, Highland Park Station, Louisville, Ky. According to the producer, the mats are made of continuous glass fiber strands.

The glass fiber mats are recommended for use in such plastics products as luggage, lamp shades, table tops, shower enclosures, women's accessories, kitchen counter tops, wall coverings, corrugated paneling, seat covers, light diffusers and appliance parts.

The mats are supplied in standard widths of 42, 48 and 60 in. in rolls 110 ft. long.

New Device Speeds Testing of Coatings

In order to better evaluate the adhesion properties of protective coatings on aircraft, the National Bureau of Standards, under the sponsorship of the Navy Bureau of Aeronautics, recently made a study of available adhesion measuring instruments. One of the promising instruments investigated is the adherometer which measures the force required to strip a coating from a metal surface.

To increase the speed, ease and

precision with which adherometer measurements can be made, A. G. Roberts and R. S. Pizer, of the NBS Plastics Laboratory, developed an electronic averaging device known as the Integrometer. This device converts the variable stripping force measured by the adherometer into electric impulses. These impulses are then added up to give a single average value which can be read directly from a standard recorder.

The two investigators find that the Integrometer, consisting of a Wheatstone bridge circuit, a strain gage, an amplifier, an integrating circuit and a meter circuit, increases the speed and precision of adherometer measurements In addition, the Integrometer is expected to provide a more reliable basis for interpretation of adherometer data.

Epoxy Heat Resistance Boosted by Additive

Epoxy resin parts with improved heat aging characteristics are said to result from use of a new epoxy resin flexibilizer that becomes a permanent part of the resin. The flexibilizer is said to eliminate plasticizer loss and consequent embrittlement of epoxy resin parts during high temperature aging. Called Cardolite NC 513, the flexibilizer is also said to extend the resin's pot life and re-

ELECTRICAL PROPERTIES OF FLEXIBILIZED EPOXY

Cardolite No. 513 in Epoxy Resin, % ➡	0	13
Dielectric Strength, v/mil....	680	790
Volume Resistivity, ohm-cm..	4×10^{13}	8×10^{13}
Power Factor		
73 F..................	0.8	0.6
175 F..................	1.6	1.3
212 F..................	2.7	2.1
Dielectric Constant		
73 F..................	4.0	3.8
175 F..................	4.3	3.9
212 F..................	4.4	4.1

duce resin viscosity. The electrical properties of flexibilized epoxy resins begin to fall off when the total resin contains more than 20% flexibilizer.

Developed by Irvington Chemical Co. Div., Minnesota Mining and Mfg. Co., 500 Doremus Ave., P. O. Box 5098, Newark 5, N. J., the flexibilizer is a clear, deep amber, liquid resin that has epoxy groups in its chemical structure. According to the producer, the flexibilizer can be cured using the same curing systems and times that are commonly used with epoxy resins.

The material is suggested for use in encapsulating electrical parts, tooling applications, plastics forming molds, adhesives, patching and splining compounds, glass fiber-reinforced compounds and coatings.

Urethane Compounds for Spray Gun Coating

Development of special urethane formulations for spray gun coating of flat and contoured surfaces has been announced by American Latex Products Corp., 3341 W. El Segundo Blvd., Hawthorne, Calif. The urethane formulations, designated Series 1900 Stafoam, are said to foam in place to any

Workman sprays *a metal panel with a special sprayable urethane foam formulation.*

your 5 keys to better Molding, Extruding, Calendering

CYCOLAC®

HIGH IMPACT THERMOPLASTIC RESIN

Already used extensively in a host of end-use products, Cycolac now provides an easy solution to many product cost and quality problems. With added scientific refinements, Cycolac offers five types, each designed to serve specific requirements.

Write for Latest Technical Data Today!

NOW! 5 TYPES FOR MORE SPECIFIC END-USE APPLICATIONS

TYPE R Especially suited to parts requiring maximum hardness, *rigidity*, tensile strength, resistance to heat-distortion.

TYPE T Excellent for use in items where greatest *toughness* at high hardness and tensile-strength levels is essential.

TYPE H Extraordinary *high impact*-strength over a wide range of temperatures. Fine for high-impact extruded sheet and injection-molded items.

TYPE L Extensive applications in extruded pipe and tubing . . . intricate profile extrusions . . . calendered sheet. Low brittle point.

TYPE LT Exceptional *low temperature* properties; non-brittle even in sub-zero temperatures. Applications include miscellaneous extrusions, calendered sheet.

PACESETTER IN
Marbon CHEMICAL
SYNTHETIC RESINS

Division of BORG WARNER • Gary, Indiana

also represented by:

WEST COAST: Harwick Standard Chemical Co., Los Angeles, Cal.
CANADA: Dillons Chemical Co. Ltd., Montreal & Toronto
EXPORT: British Anchor Chemical Corp., New York

For more information, turn to Reader Service card, circle No. 525

desired thickness between ⅛ and 2 in., forming a surface bond stronger than the material itself.

The sprayable urethane foams are suitable for use as thermal, sound and electrical insulation. They are available in densities ranging between 2 and 20 lb. per cu ft, either in rigid or semi-rigid forms.

Copper-Clad Teflon for Printed Circuits

Fluorocarbon Products, Inc. Div., United States Gasket Co., Camden 1, N. J., has introduced a line of copper-clad Teflon sheets and tapes for printed circuit and cable strip applications. The material, designated Chemelec Copper Clad Teflon, is said to provide a uniform dielectric constant over a given area. In addition, it has good bond strength, low water absorption and low dissipation factor.

The copper-clad sheet is available 18 in. wide by 36 in. long in thicknesses of 1/16, ⅛ and 3/16, with 1 or 2 oz copper on both sides. The tape is available 12 in. wide by 36 in. long in thicknesses of 0.005, 0.010, 0.015, 0.020, 0.030, 0.045 and 0.060 in., with 1, 2 or 3 oz copper on one or both sides.

Viton A-Coated Fabrics Resist Heat, Fuels

Three fluoro-elastomer coated fabrics, trade named Fairprene, show good resistance to deterioration by heat, chemicals, aircraft and automotive fuels, lubricants, ozone and weathering. The new materials, available in limited quantities from E. I. du Pont de Nemours & Co., Inc., Fabrics & Finishes Dept., Wilmington 98, Del., are claimed to withstand total immersion in most fluids at

Tool Steel Topics

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

Brake Die saves shop time in forming overlap for steel spout

The problem sounded simple enough — putting an overlap in a section of 20-gage stainless steel, which was then formed into a spout for use in meat-packaging tables. But getting a tool steel which could do the job more economically than the grade formerly used was somewhat of a challenge for the manufacturer, J. B. Dove & Sons, Inc., Philadelphia.

The answer was Bethlehem Brake Die, supplied by our local tool steel distributor, Hill-Chase & Co. Because of Brake Die's easy machinability and good wear-resistance, the new die minimized manufacturing costs. It also helped in producing a better-looking product. Said one of the Dove engineers: "We like Brake Die. It's doing a good job for us."

Brake Die, a special alloy steel, is oil-quenched and tempered to develop a fine balance of mechanical properties. It's ideal where wear-resistance, toughness, resistance to impact and good machinability are required.

Typical Analysis

Carbon 0.50	Manganese 0.90
Chromium 1.00	Molybdenum 0.20

Chances are there might be one or more applications in your shop right now where Brake Die steel could be used to good advantage. Why not talk it over with your Bethlehem tool steel distributor?

BETHLEHEM TOOL STEEL ENGINEER SAYS:

How to Shrink-Fit Tool Inserts

Shrink-fitting of tool steel inserts is a procedure which is being widely used to improve the service life of tools. Shrink-fitting is most applicable to rings and cylinders, such as are used in heading and drawing operations where the tools can be shrink-fitted into large retaining rings. The shrink-fit sets up radial compressive stress in the tool, which is available to oppose radial tensile stress set up in service, and thereby improves the performance as compared to solid tools which are not pre-stressed. Shrink-fitting of tools should be carried out as follows:

1. The retainer must be of adequate diameter and strength to provide the stresses required on the tool insert. This generally means that an alloy steel capable of hardening to approximately 300/400 BHN must be used. Shock-resisting tool steels heat treated to approximately Rockwell C 48 to 52 are used on heavy duty applications. It is recommended that the OD of the retainer be a minimum of twice the ID (preferably three times the ID).

2. A shrink-fit allowance of .003/.004 in. per in. should be provided for. This means that the OD of the insert is .003/.004 in. per in. larger than the ID of the retainer into which it must fit. These dimensions must be carefully maintained in order to obtain the benefits of shrink-fitting.

3. The OD of the insert and the ID of the retainer should have a smooth finish, preferably produced by grinding.

4. The retainer should be heated to a temperature sufficient to cause the expansion necessary to assemble the insert. Care should be exercised not to exceed the tempering temperature used in heat-treating the retainer. If necessary, the insert may be sub-zero cooled to aid in providing the clearance required for assembly.

5. After assembly of the parts, cooling of the assembly should be rapid enough to prevent over-tempering of the insert by heat transferred from the retainer.

For more information, turn to Reader Service card, circle No. 466

temperatures above 300 F. The three fabrics, a glass fabric, a Dacron polyester fabric and a Teflon coated glass fabric are coated with Viton A, a new fluorinated rubber produced by Du Pont. (For more information on Viton A, see MATERIALS IN DESIGN ENGINEERING, July '57, p 96.)

According to Du Pont, the initial application for the material is expected to be aircraft diaphragms and gaskets. The company says that the coated fabrics may also find use in the construction of fuel cells, equipment linings and protective clothing.

Viton A-coated fabrics are supplied fully vulcanized in 36-in. widths and are priced at $25 to $60 per yd, depending on gage.

Extruded Nylon Rods for Electrical Devices

An improved grade of extruded nylon rod is available from National Vulcanized Fibre Co., 1057 Beech St., Wilmington 99, Del. The nylon, known as Grade 31, has good electrical properties and low water absorption. It is recommended for use as cams, gears, bushings, nuts and washers in electronic instruments, radios, television sets and other electrical equipment. The extruded rods are available in diameters from 1/4 to 2 in. and in lengths from 3 to 6 ft.

PROPERTIES OF GRADE 31 NYLON

Tensile Strength, psi	7000
Elongation, %	90
Compressive Strength, psi	3000
Flexural Strength, psi	8000
Modulus of Elasticity, psi	260,000
Izod Impact Strength, ft-lb/in	1
Shear Strength, psi	8400
Rockwell Hardness	R111
Dielectric Strength, v/mil	
Short-Time	470
Step-by-Step	410
Dielectric Constant	
60 Cycles	4.6
10^3 Cycles	4.5
10^6 Cycles	3.5
Flow Temperature, F	397
Water Absorption, %	2.2

For more information, turn to Reader Service card, circle No. 415

MATERIALS AT WORK

Plastics boat—continued from p 12

three sections: port, starboard and center sections. The transverse framing is made by laying up a glass-resin mixture over isocyanate foam cores. To avoid the necessity of gluing slabs of foam into blanks and then machining them, frame templates are simply finished with two strips of material to form a box in the shape and to the contour of the frame core. The core boxes are then filled with foaming material and the cores are cast to shape.

The deck and bulkheads are composed of honeycomb structures faced with reinforced polyester skins. They are formed by laying up the first skin on a mold, putting paper honeycomb in place, filling in local areas that need reinforcement for bolts, etc., and then applying the top skin. Cure is accomplished by placing a vinyl sheet vacuum blanket over the lay-up and subjecting it to elevated temperatures. The deckhouse, deckhouse hatch and three-section engine room are of single skin construction, also formed by the vacuum blanket process.

Advantages

In addition to the usual advantages of strength, light weight and durability, the new glass-polyester boat is resistant to fire and the corrosive effects of salt water; requires a minimum of maintenance; and is claimed to have a service life 50% greater than similar wood or steel craft.

Aluminum Lumber Rolls Reduce Truck Weight

The replacement of steel by aluminum for the rolls used on trucks and trailers to transport lumber has resulted in substantial reductions in truck weight as well as an increase in carrying capacity.

In addition to the fact that alu-

MATERIALS AT WORK

Linde Air Products Co.
Aluminum lumber rolls *installed on a trailer.*

minum rolls provide a weight reduction over steel of approximately 3500 lb per set, experience has shown that the aluminum rolls wear better than steel because of their greater flexibility and tendency to maintain alignment under heavy loads. A set of aluminum rolls put in service in 1954 is still in excellent condition.

The aluminum rolls, fabricated by H. B. Reubans Welding & Machine Shop, are welded by the argon-shielded technique using drawn aluminum rod.

Epoxy Resins Double As Mold and Casting

A technique employing the use of epoxy resins and hardeners in a dual role has cut by more than half the normally high cost of prototypes and short run production items. The epoxy resins are used to make both the production molds and the products cast from them.

The epoxy mold, epoxy casting

Bakelite Co.
Epoxy mold *has four sections.*

An 8' diameter Meehanite surface plate casting made by Fulton Foundry & Machine Company, Inc. of Cleveland is used for checking roller bearing parts. This casting was finished without aging or heat treating and has retained its original accuracy after many years of use.

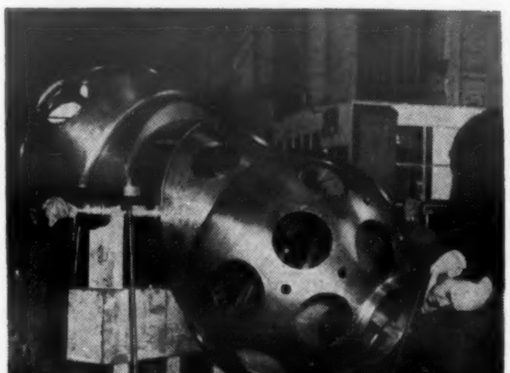
Meehanite castings maintain dimensional stability

Maintenance of accuracy of dimension is of first importance in modern engineering components. Meehanite metal has found wide favor with design engineers because it exhibits an unusually high degree of stability in the "as cast" and also in the hardened condition.

In addition to dimensional stability, the uniform solidity, greater strength, rigidity and shock resistance of Meehanite metal permits advantageous design changes and substantial reductions in casting weight.

Although structurally similar to high grade carbon tool steel, Meehanite metal contains graphite particles in controlled quantity and shape. This assures dense and uniformly solid castings regardless of weight or dimension.

If you have a question concerning the use of Meehanite® in your casting design, consult a Meehanite foundry and write today for your free single copy of "Casting Design As Influenced By Foundry Practice."



Meehanite® was selected in the construction of the Morrison Planetarium Projector because of its ability to maintain dimensional stability. These castings were made by Vulcan Foundry Company of Oakland, California.

MEEHANITE BRIDGES THE GAP BETWEEN CAST IRON AND STEEL®

MEEHANITE METAL

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK

MATERIALS AT WORK

Bakelite Co.

***Liquid epoxy** is poured after sections of mold are clamped together.*

technique, as used by Fisher Engineering, Inc. to produce a 5.5-v filament transformer, involves a four-section mold. As shown in the photo on p 238, each section is given a metal insert for accurate positioning. The sections are then clamped together to form a low cost mold into which compounds based on epoxy resins can be quickly poured (see above photo) and cured at room temperature.

The most important characteristic of epoxy that makes it ideal for this type of production is that it will harden into almost any shape without the use of pressure or high temperatures.

Silver Brazing Makes Fishing Reel Stronger

The switch from a bronze rivet assembly to silver brazing has enabled Montague-Ocean City Rod & Reel Co. to more than double the strength of the handle assembly used on two of its medium size, big game fishing reels.

The former assembly (Fig. 1) consisted of a plastics handle knob which rotated on self-lubricating bronze bearings around a long bronze rivet and was held in place by the head of the rivet. The lower end of the 0.2-in. dia rivet was reduced to 0.15 in. to

MATERIALS AT WORK

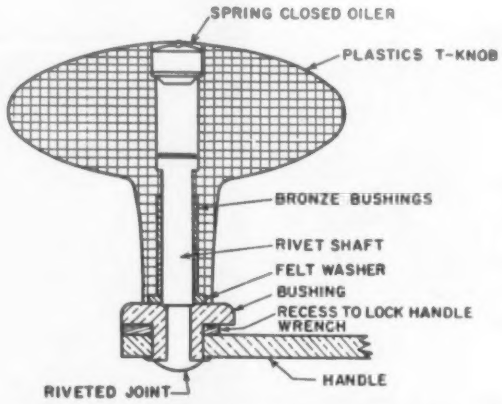


Fig 1—Old design showing reduced diameter of rivet at joint.

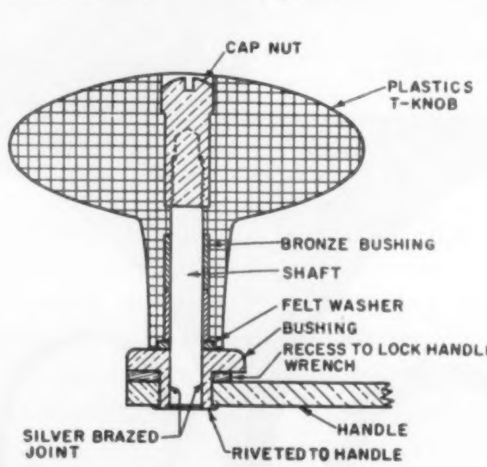
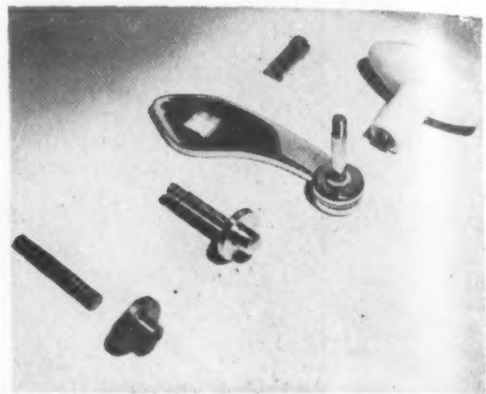


Fig 2—New design showing full-diameter brazed joint.

provide a shoulder against a large brass bushing which extended through the crank handle of the reel. The assembly was joined together in one operation by heading over both the rivet to the bushing and the bushing to the handle.

This design led to serious problems. To permit rapid rewind, fishing reels are designed so that the gear ratio is about 1:2, or greater; as a result, in order to deliver a given force to the gear train, much greater forces must be generated at the handle. With the old design, such forces produced a severe bending moment on the reduced diameter of the rivet and failures started to occur.

By using silver brazing to replace the rivet, the assembly was strengthened. Since the resistance of a circular section to bending varies with the cube of the diameter, the strength of this joint was more than doubled by retain-



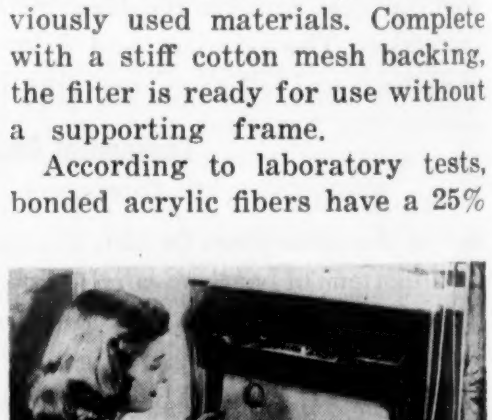
Components of fishing reel *handle assembly. Shaft and bushing before and after brazing are in foreground.*

ing the full 0.2 in. dia at the base instead of reducing it to 0.15 in. As shown in Fig 2, the shaft is now brazed into the bushing. Not only is the shaft stronger, but also the joint is stronger since there is now more joint area.

Acrylic Fiber Filters Are Efficient, Durable

Filter replacements for air conditioners are now being made of Union Carbide Corp.'s Dynel arcylic fibers. The new filters are easy to handle and cut to size, and are said to last longer and filter air more efficiently than previously used materials. Complete with a stiff cotton mesh backing, the filter is ready for use without a supporting frame.

According to laboratory tests, bonded acrylic fibers have a 25%



Filter is easily cut *and installed in air conditioning unit.*

How you benefit from Electro-Alloys'

ENLARGED MACHINING AND CLEANING ROOM FACILITIES

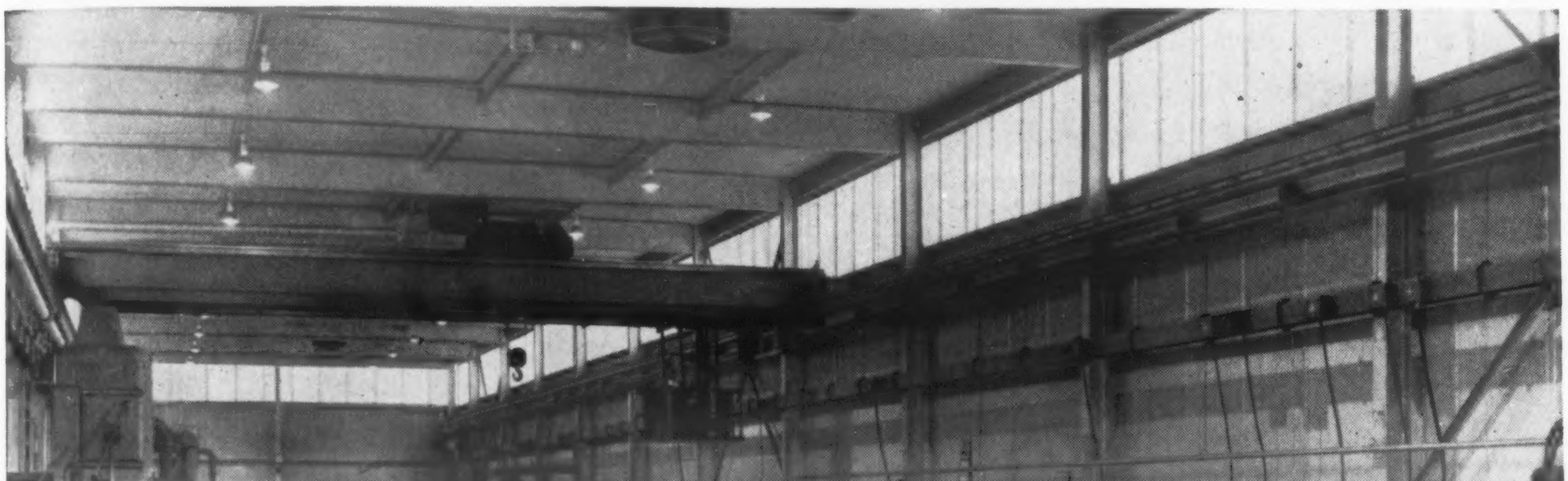
Thermalloy high-alloy castings* are being produced in greater variety, size and quantity than ever before. To meet the increasing demands of our customers, new and enlarged machine shop and cleaning room facilities have recently been installed.

What does this mean to you? It means we can handle more and varied jobs faster. We can machine large castings to your specifications on the most modern type of equipment . . . lathes, shapers, milling machines, key seaters, drill presses, planers, grinders.

Our new cleaning room addition includes Wheelabrator tumbling machine, abrasive cutoff machines, grinders, welding booths and casting storage. It is serviced by a crane to facilitate handling of large castings.

Why not take advantage of these enlarged, modern facilities on your next high alloy casting job? Call your nearest Electro-Alloys representative, or write us direct for information and quotes. Electro-Alloys Division, 80210 Taylor Street, Elyria, Ohio.

*Reg. U.S. Pat. Off.



AMERICAN Brake Shoe COMPANY

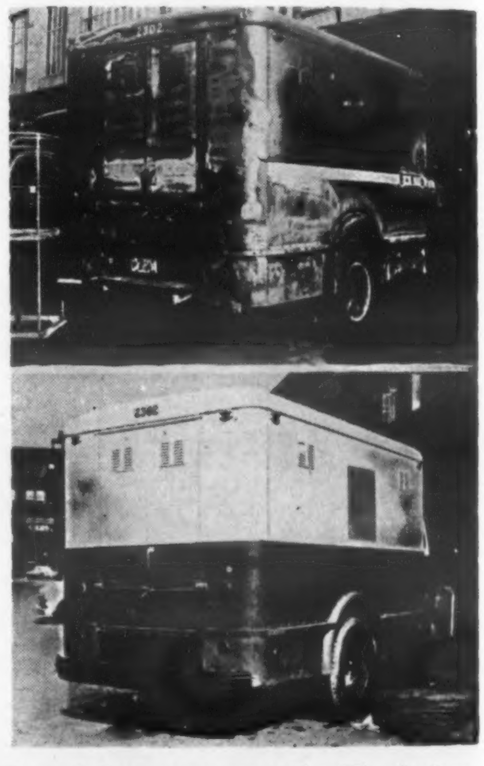
ELECTRO-ALLOYS DIVISION Elyria, Ohio

For more information, turn to Reader Service card, circle No. 362

greater dust holding capacity with the same or higher air filtering efficiency than other filter materials. Individual size filters are cut from one 15 x 24 x ½-in. thick sheet and are easily installed (see photo on p 244).

Glass-Silicone Hose Withstands 600 F

Shown in the photo on p 248 is a section of radiator hose currently being used in diesel engines. The



Repairing compound—The before-and-after photos shown above illustrate the effectiveness of a relatively new patching compound developed by Reichhold Chemicals, Inc. There are several types of compound available—for patching tears or dents—but the basic ingredient in each is polyester resin.

The patching process is very simple involving nothing more than simply impregnating a fibrous glass cloth with a mixture of polyester resin and milled glass fibers, applying the mixture to the damaged metal area, and allowing the patch to harden. The patch is then sanded, painted and polished.

SPECIAL SERVICE ON REPLACEMENT ORDERS

When down-time runs into dollars with every minute, *special service* on replacement orders means substantial savings to Damascus customers.

This special service is possible because, as a supplier of tubing for original equipment, Damascus can frequently fill orders immediately from mill inventories. Where pipe or tubing required is not on hand, a large inventory of stainless strip usually permits Damascus to complete your order within days. Damascus doesn't have to wait for delivery from the strip mill.

When you need tubing in a hurry, call Damascus. We can quote delivery and prices over the phone.

Write for free booklet.

FORMED STEEL TUBE INSTITUTE FSTI

DAMASCUS TUBE COMPANY

STAINLESS STEEL TUBING AND PIPE

GREENVILLE, PENNSYLVANIA

For more information, turn to Reader Service card, circle No. 412

MATERIALS AT WORK

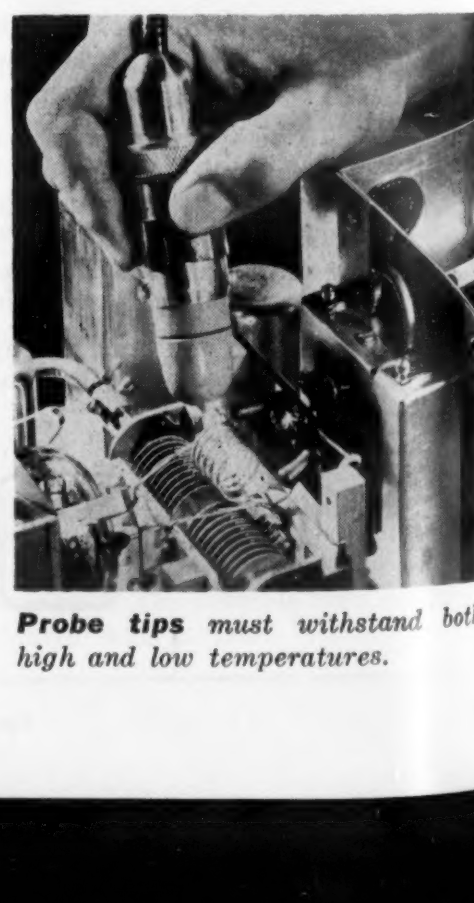
Section *of glass-silicone hose.*

new hose, developed by Hewitt-Robins, Inc., is made of fibrous glass-reinforced silicone. It is claimed to withstand temperatures above 600 F and to have a burst strength of more than 600 psi.

Irradiated Polyethylene Cuts Probe Tip Cracks

By switching from polystyrene to irradiated polyethylene for the probe tips used on high frequency vacuum tube voltmeters (see photo below), Hewlett-Packard Co. has eliminated the problem of low temperature cracking.

Polystyrene probe tips, which were used at both high and low temperatures, tended to crack at low temperatures as a result of the different rates of expansion of imbedded electronic components. Polyethylene eliminated this problem; however, the tendency of conventional polyethylene to flow at



Probe tips *must withstand both high and low temperatures.*

LOOK INTO THE NEW GRAYS

for tub and oven interiors

The smooth, attractive finish of the new gray vitreous enamel ground coats will give you one good reason why they're becoming more popular. On the practical side, they have better resistance to alkalies — keep their good looks longer.

Using TAM OPAX* and OPAX S* as the mill addition opacifier — a number of finishers report enamel working properties they are unable to get by any other means.

Reason enough to write for a sample package of OPAX.* Your request to our N.Y.C. office will receive prompt, personal attention.

TAM PRODUCTS
Registered U.S. Pat. Off.

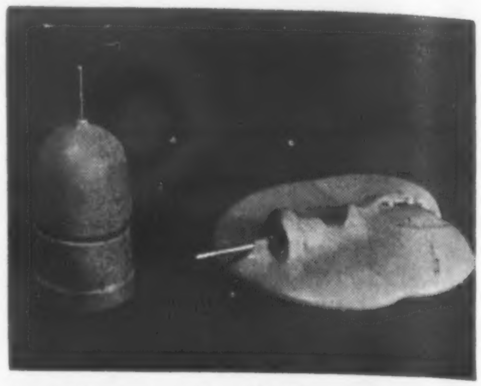
TITANIUM ALLOY MFG. DIVISION
NATIONAL LEAD COMPANY

Executive and Sales Offices:
111 Broadway, New York City

General Offices, Works and Research Laboratories:
Niagara Falls, New York

*Registered trademarks

For more information, turn to Reader Service card, circle No. 565



Irradiated polyethylene *(left) and non-irradiated polyethylene (right) after 30-min exposure to 400 F.*

high temperatures restricted its use under high ambient conditions and in applications where the probe tips are soldered directly into the electronic circuit under test.

Irradiation, administered by Applied Research Corp., increased polyethylene's service temperature to about 250 F, with little effect on its resistance to low temperature cracking.

Teflon-lined steel pipe—Shown above is a section of teflon-lined steel piping which is currently solving severe corrosion problems in food and chemical processing, pharmaceutical, textile, metal finishing and beverage equipment. Manufactured by Haveg Industries, the piping is said to be impervious to the attack of nearly all acids, chemicals, solvents and caustics. It will withstand temperatures up to 400 F at pressures of 300 psi.

PRICES AND SUPPLY

The Outlook by Herman B. Director, *Consultant, Washington, D. C.*

Natural rubber price may drop

The price of natural rubber, which is about 8-9¢ per lb higher than the price of synthetic rubber, may be reduced as a result of increased competition. For one thing, use of the new synthetic butyl, which is known in the industry as "synthetic natural rubber," is becoming more widespread. Polymerized butadiene is also getting increased use. Finally, and perhaps most important, new plants for synthetic rubber are continually being constructed and there are certain to be new gains in technology with resultant further reductions in the price of synthetic rubber.

As a result, natural rubber producers are attempting to: 1) improve research and customer service, 2) renew enforcement of quality standards on shipments, and 3) reduce export taxes in producing countries so that the natural product will be more competitive. The natural rubber industry seems to be aiming for a price of about 18-20¢ per lb f.o.b. The average price of natural rubber during the month of September was around 32-33¢ per lb.

Abundance of copper more pronounced than ever

Although copper prices on the London market have dropped to the lowest level in several years, consumption has not increased. The argument as to whether lower prices retard sales in anticipation of still lower prices is largely academic, as is the argument that the quoted price is actually lower than the market itself warrants. The simple fact is that copper production in virtually all areas of the world has been increased far beyond industrial demand for this material. Moreover, the British are now dumping copper on the market, and the U.S. Government is showing little interest in purchasing copper for its stocks even though the material is now on the official barter list in connection with the U.S. Government's program for disposing of surplus agricultural commodities in exchange for "strategic materials."

The price of copper is now at the level at which the U.S. Government *must* begin to take substantial quantities under its guaranteed market price program inaugurated in the early stages of the Korean War. However, adding copper to the barter list is not likely to have any more effect on the price of copper than similar action had in connection with lead and zinc.

One sure indication of the seriousness of the overabundance of copper is the action taken by the Chileans to export copper wire to the USSR. Because copper is an essential ingredient in the manufacture of virtually all implements of war, it has been on the forbidden list since the start of the "cold war."

Aluminum in plentiful supply

Although aluminum production in Canada has been decreased by about 900,000 tons as a result of the recent strike at Alcan's Armida Works, U.S. consumers have had no trouble getting the material. There are two good reasons for this: 1) although 900,000 tons represents 45% of Alcan's capacity, Alcan had large stocks on hand and was able to meet its commitments; 2) there is a pronounced abundance of aluminum in this country. In fact, a 300,000-ton surplus is expected throughout the free world by the end of the year.

Consumption of urethane foam increasing

Flexible and rigid urethane foam materials are replacing more and more foam rubber and vinyl in automobiles, furniture, refrigerators and clothing interliners. One reason for this is that urethane foam now costs less than foam rubber. As a greater volume production is reached, we are likely to see even more price reductions.

Steel consumption increasing, supply still ample

Consumption of steel in the third quarter was consistently above industry estimates, and it is unlikely that steel production will drop to the 70%-of-capacity

PRICES AND SUPPLY

The Outlook—continued

level widely forecast earlier this year. Production in July averaged over two million tons per week and turned out to be the third highest July in history. And although the automotive industry is getting off to a somewhat slower start this year than it did last year, indications are that it will consume more steel in the fourth quarter of 1957 than it did in the similar period of 1956. In fact, we estimate that enough steel will be used to build 6,200,000 cars, even though sales may lag.

In other areas of steel consumption, all signs point to record levels. Steel used in construction, for example, is expected to exceed last year's all-time high; it is already 5% above. Use of heavy steels is high, alloy and stainless demands are increasing, and, should the Government reduce oil imports, the demand for steels for drilling would certainly increase. In addition, there was a marked increase in consumption of steel for appliances just after Labor Day. (However, the appliance industry will probably use about 15% less steel this year than it did last year.)

In spite of these increases in steel consumption, the steel industry's capacity to produce steel in virtually every product line makes it certain that even high level consumer demands can be readily met.

Director says . . .

- Statistics published by the Census Bureau bear out the contention that as production of plastics has increased in volume, the consumer has benefited through increased productivity resulting from large scale mass production.
- The current decrease in aluminum consumption is likely to keep producers from passing on the increased cost of pig aluminum to consumers via increased prices for aluminum products.
- We have now passed the point where design engineers should sacrifice performance on the grounds that nickel will continue in short supply.
- Despite the increase in steel consumption expected when the automobile industry reaches its full production stride this fall, we anticipate little more than a stretch-out in steel delivery times.
- There is little indication that U.S. producers will accept in any sizable quantity the large steel orders expected from foreign shipbuilders.

Industrial diamond supplies may increase

The prospects for increased supplies of industrial diamonds are good. For one thing, substantial progress has been made in the development of a manufactured industrial diamond suitable for use in grinding wheels. For another, the Soviets have announced an important discovery of sources of industrial diamonds inside the Soviet Union. Development of these deposits could change the supply picture markedly because, even though the export of industrial diamonds to the USSR has been embargoed, reports indicate that industrial diamonds have been smuggled into Communist countries from Western Europe. If the new deposits are sufficient to satisfy Soviet needs, as well as provide quantities for export, supplies of industrial diamonds should improve.

Prices of secondary materials continue to drop

As a result of increased supplies, prices of secondary materials (especially nonferrous metals such as aluminum, brass, copper and nickel) continue to decrease. An outstanding example is secondary nickel, which is now selling at prices below that of the primary metal. New nickel clips, for example, which sold in 1956 for as high as $2.20 per lb, are now quoted at 70¢ per lb —4¢ per lb less than the quoted market price for primary nickel.

Although there are still substantial quantities of primary nickel being sold above market prices, it is becoming increasingly more difficult for the Government to dispose of high priced nickel produced by facilities whose production was guaranteed by the Government in the last few years. There seems to be little interest on the part of nickel consumers to increase their usage of nickel, in spite of all earlier indications that as soon as nickel became more readily available there would be an immediate demand to use all of the nickel available.

Aircraft cutbacks mean more materials for industry

One result of production cutbacks in the aircraft industry will probably be that more materials will be available for civilian uses. Included among those materials are titanium, heat resistant alloys, aluminum, nickel and copper.

More tantalum this fall

This fall there will be a 100% increase in the supply of tantalum used in the manufacture of capacitors for electrical and electronic applications. The material will be made available first as powder and then in the form of mill shapes.

Tin price approaches support level

The decrease in tin consumption has forced the price of tin to a level not far above the price at which the Buffer Stock Manager must purchase tin for his stocks. The outlook is for a surplus of tin for 1957.

Nonferrous Metal Prices: Past, Present, Future

U. S. PRODUCTION AND CONSUMPTION OF COPPER, LEAD AND ZINC (1000 tons)

Metal ↓	1956		1957[a]	
	Production	Consumption	Production	Consumption
Copper	1100	1466[b]	575	674[b]
Lead	348	1182	180	570[c]
Zinc	538	869	280	372

[a]First half only. [b]Deliveries to fabricators only. [c]Estimated.

Nonferrous metal prices have fallen sharply since the beginning of the year: on Jan 1, producer's prices for zinc were 13½¢ per lb; for lead, 16¢; and for copper, 36¢. On July 1, prices were: zinc, 10¢; lead, 14¢; and copper, 29¼¢.

The reasons for these large reductions are fairly obvious. As outlined in a report issued by American Smelting & Refining Co., "continued production of more metal than consumers are willing to buy can only result in lower prices. When a large customer such as the United States Government, which absorbed most of the excess 1956 production, suddenly reduces its support of the market, the decline is bound to be pronounced." Recently announced cutbacks in production have been attempts at bringing supply and demand back into balance. However, the situation is presently far from resolved.

The past situation

According to Asarco, producers of copper, lead and zinc were operating at an all-time high at the end of 1956. With metal prices up, mining companies could afford to bring high cost mines into operation. Also, many new mines, developed as a result of increased consumption during the Korean conflict, were brought into production. Exploration of new areas went forward at a pace never experienced before. Furthermore, the high level of production continued for the first half of 1957.

"In 1956," according to Asarco, "the United States Government, through its stockpile and barter program, is believed to have acquired approximately 125,000 tons of lead and 260,000 tons of zinc. The barter program encompassed exchanges of foreign metal for surplus U. S. grain. These programs were continued at about the same levels for the first four months of 1957." In May of this year, further barter purchases were suspended and although direct stockpiling increased slightly, the increase was not sufficient to offset the effects of discontinued barter.

The present situation

As a result of the suspension of barter, the price of zinc dropped 1½¢ per lb and the price of lead dropped 1¢ per lb. As producers' stocks continued to mount, further price reductions were inevitable.

Most U. S. producers of zinc have announced cutbacks amounting to a total of about 20% of domestic smelter production. Foreign producers have also reduced production. However, Asarco says, "If zinc prices remain at their current level for several months, many of the higher cost mines will be forced to suspend operations."

The lead situation is not quite as severe. Consumption is expected to increase sizably over the next few months due to increased use of lead in batteries for the new automobile models and for replacements.

As far as copper prices are concerned, since the U. S. Government has not contracted for new stockpile purchases since 1954, the recent decline is directly due to rising production without a corresponding increase in demand from industrial consumers. And, although individual curtailments of copper production have been announced, there has been no significant over-all reduction from the high levels of 1956. Foreign producers, with the exception of Rhodesia, have taken no action as yet. As a result, U.S. stocks of refined copper increased from 120,645 tons at the end of 1956 to 165,549 tons at the end of June, and at the beginning of September the price dropped again to 27¢ per lb.

The future?

The Government is considering several proposals designed to cushion the effect of overabundance of materials. One proposal under study is to establish so-called "sliding scale" import taxes on lead and zinc. However, it is doubtful whether any legislation will be passed during this session of Congress. Although the Government's decision to discontinue barter purchases seems to be the main reason for the abundant supply, the consensus is that prices are not likely to increase or even be maintained at present levels unless there is an increase in consumption.

Tungsten Institute Asks for Higher Tariff

Lunsford Long, president of the Tungsten Institute, has proposed to the Senate Minerals Subcommittee a tax on tungsten imports "sufficient to establish a floor price for tungsten concentrates of domestic origin of good grade of at least \$45 a short ton unit of tungsten trioxide." Mr. Long says that the present tariff of \$7.93 per short ton unit is "entirely inadequate. . . No tungsten producer in this coun-

(continued on p 262)

Prices of Materials

Changes since last month are bold-faced

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.65	.44-.54
Butadiene-Styrene	.17-30	.26-.32
Butyl	.23-.28	—
Neoprene[a]	.39-.75	.37-.47
Silicone[a]	1.90-4	—
Polysulfide[a]	47-1	.70-.92
Natural	.33[b]	—

[a]Less than carload quantities.
[b]Average spot price for month of July.

GLASS FOR REINFORCED PLASTICS

Fabric ($/yd 38 in. wide)[a]	
112 Woven	.48
181 Long-shaft satin weave	.03
143 Unidirectional	1.00
Roving[a]	
Continuous	.40
Continuous spun strand	.36
Continuous chopped spun	.38
Milled fibers (1/32-¼ in.)[a]	.45
Mat	
Chopped strand (2 in.)[a,b]	.52-.72
Surfacing ($/1000 sq ft)[c]	10-19
Continuous chopped strand (¼-2 in.)	.40

[a]Price includes binder or finish.
[b]Price varies with binder.
[c]0.010-0.020 in. thick.

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.34-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.40	.17-.34
Polyester	.42	.32-.50
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.33	—

[a]60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250 in.)	Rod		Tube	
			⅛-¼ in.	⅜-1¼ in.	⅛-¼ in.	⅜-1¼ in.
Acrylic	.51-.59	.49-2.15	.90-1.15	.80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.65	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.50-.72	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.51-.63	—	—		—	
Fluorocarbon						
CFE	7-8	15-23	18-22	14-20	20-22.50	16-20
TFE	4.50-7.45	14.30-11	13	13	13	13
Nylon	**1.18**-2.30	—	3	3	3	3
Polyethylene	.35-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	.26-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.27-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Pig (99-99.9%)	.26-.28
Ingot (99-99.9%)	**.28-.30**
Foil (5-0.5 mil)	.55-.77
Alloy Ingot (13, 43, A132, 214)	.29-.32
Sheet (1100, 3003; 3-0.03 in.)[a]	.40-.45
Plate (1100, 3003, 5050, 3004, 5052)[a]	.40-.43

[a]Mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	**.44**	.47	.48
Seamless Tubing	**.47**	.50	.51
Rod (not f.c.)	.44	.47	.48
Wire	.45	**.47**	**.48**

COPPER

Ingot (elec)	.29
Sheet, Strip (hot rolled)	.51
Seamless Tubing	**.51**
Rod, Drawn	**.48**
Rod, Free Cutting	**.57**
Wire	
Round	**.34**
Square, Rectangular	**.37**
Magnet	**.41**

LEAD

Common Grade	.14

MAGNESIUM

Pig (98.8%)	.36
Ingot (98.8%)	.37
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41[a]

[a]Delivered price.

NICKEL

Form	"F"	"A"	Monel
Ingot	75[a]	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.26	1.06
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

[a]Delivered price.

TIN

Primary[a]	**.93-.94**

[a]Delivered price.

(continued on p 258)

PRICES AND SUPPLY

TITANIUM

Sponge (99.3+%)	2.00-2.50
Bars, Rod	6.15-6.40
Plate	8.00-10.75
Sheet, Strip	6.50-11.10
Wire	7.50-8.00

ZINC

Primary[a]	.10½[c]
Die Casting Alloys[b]	.15-.16
Sheet	.24
Ribbon	.21
Plates	.19

[a]Prime Western—Special High Grade.
[b]Alloys 2, 3, 5. [c]Delivered price.

METAL POWDERS

Aluminum [a,b]	.36
Brass [a]	.37-.41
Copper (elec or red.)[a]	.43
Columbium	120
Molybdenum (98%)	3.80-4.10
Nickel	1.05
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	4-5[c]
Zirconium	
Flash Grade	11.50
Electronics Grade	15

[a]Price for —100 mesh. [c]Delivered price.
[b]Freight allowed.

OTHER NONFERROUS METALS

Cadmium (bars)	1.70
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.34[a]
Palladium	$23-24/troy oz
Platinum	$84-87/troy oz
Silver	91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium	3.45
Zirconium (sheet, strip, bar)	27-35

[a]Delivered price.

IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	77
Billets, Blooms, Slabs	
Carbon, Re-Rolling	77.50
Carbon, Forging	96
Alloy, Forging	114
Seamless Tube Rounds	117.50
Wire Rods	$6.15/cwt

(continued on p 260)

FINISHED STEEL ($/cwt)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.10	7.62	7.20
Sheet, H.R.	4.92	7.27	—
Sheet, C.R.	6.05	8.97	—
Strip, H.R.	4.92	7.32	8.10
Strip, C.R.	7.15	10.65	—
Bar, H.R.	5.42	7.92	6.47
Bar, C.F.	7.30	—	8.77

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.38-.41	.44-.48	.46-.51	.51-.59
321[a]	.47	.56	.60	.66
347[a]	.56	.65	.70	.80
Martensitic				
410[a]	.28	.34	.35	.40
416	.29	.34	.35	.47
403	.32	.38	.40	.48
420, 440	.34	.41	.45	.62
Ferritic				
405, 430, 430F[a]	.30	.34-.35	.36-.38	.41-.47
442	.32	.38	.40	.56
431	.30	.35	.46	.54
446	.38	.45	.46	.67
High Mn				
202[a]	.37	.43	.45	.49
Extra Low C				
304L	.48	.56	.59	.63
316L	.64	.74	.78	.82
Precip Hard.				
17-7PH	.66	.73	.85	.90

[a]Ingot prices approx 60% of forging billet price.

METAL POWDERS ($/lb)[a]

Sponge Iron	.10-.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.34
Stainless Steel	
304	1.08
316	1.44

[a]Price for −100 mesh.

IRON ($/gross ton)

Pig	65-66

(continued on p 262)

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	10.05-10.30
Electrolytic (0.25-0.75 lb)	8.75-9.40
Black Plate	7.85-7.95

FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Re-quired[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.50
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified			
Alkyd	1.5	1.5	1.50
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.00
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.50
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.50
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.50
Vinyl	1.0	2.0	2.50
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

[a]Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice.
[b]Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.

Tungsten—continued

try can operate at the current world market price of $14 a short ton unit."

Mr. Long indicated that only four tungsten mines are currently in operation in the United States, as against 700 mines which produced 15.8 million pounds of tungsten in 1955. He

blamed "this stagnation in the tungsten industry" on the Government's failure to continue a tungsten support subsidy.

Although the Senate strongly endorsed the program, the House of Representatives adamantly refused to continue the tungsten program in this session of Congress.

World Production of Beryl Up 40%

World production of beryl, the only commercial-source mineral of beryllium, reached an all-time high of 12,500 short tons in 1956 —about 40% higher than the previous high established in 1955.

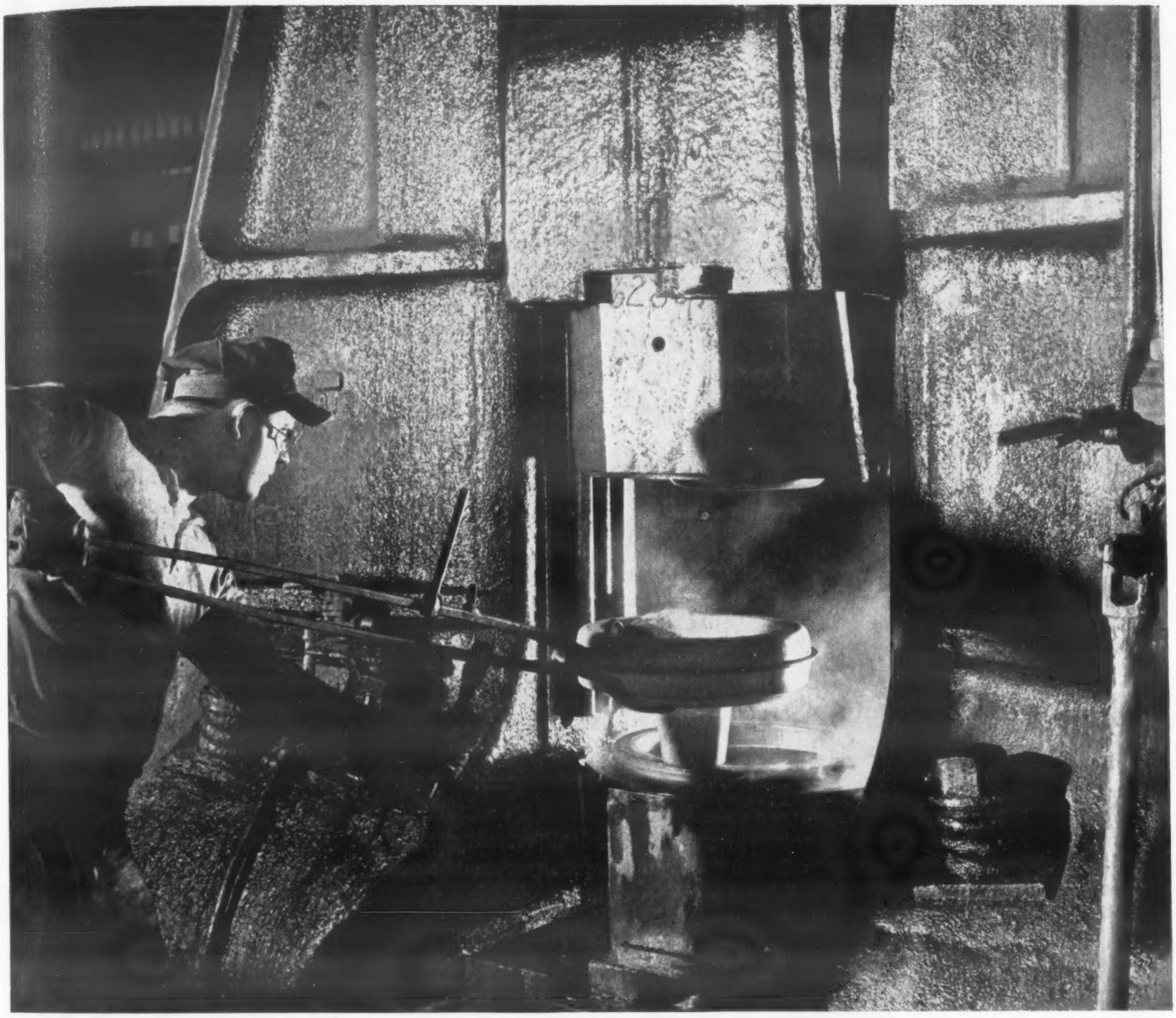
Beryl production in the United States, however, totaled only 460 tons, according to the Bureau of Mines. This was about 39% less than the record high set in 1953 and was the lowest since 1948. As a result, beryl imports into the U.S. reached a new peak of 12,371 tons and broke the previous high by almost 55%.

At present about 200 operations in 11 states are producing beryl in quantities ranging from only a few pounds to a quarter million pounds. South Dakota and Colorado lead in U.S. output.

Alloy Steel Consumption Down 18% in First Half

Although total shipments of steel were only about 5% lower in the first half of 1957 than they were in the first half of 1956, shipments of alloy steel mill products (excluding stainless) were 18% lower.

The large decrease in alloy steel consumption was due largely to curtailment by three major users: the automotive industry, industrial equipment manufacturers and warehouses. The ac-



For more information, turn to Reader Service card, circle No. 465

PRICES AND SUPPLY

ALLOY STEEL SHIPMENTS[a]
(1000 tons)

	1954	1956	1957
Jan.	328	556	482
Feb.	313	528	425
Mar.	328	577	453
Apr.	304	519	427
May	301	521	437
June	315	530	415
Total	1899	3239	2639

[a]Mill products excluding stainless.

companying table, based on American Iron and Steel Institute figures, gives actual tonnages shipped for 1954, 1956 and 1957. Figures for 1955 (not in table) indicate that there was a steady increase in mill shipments until 1957.

What's Happening In Prices and Supply

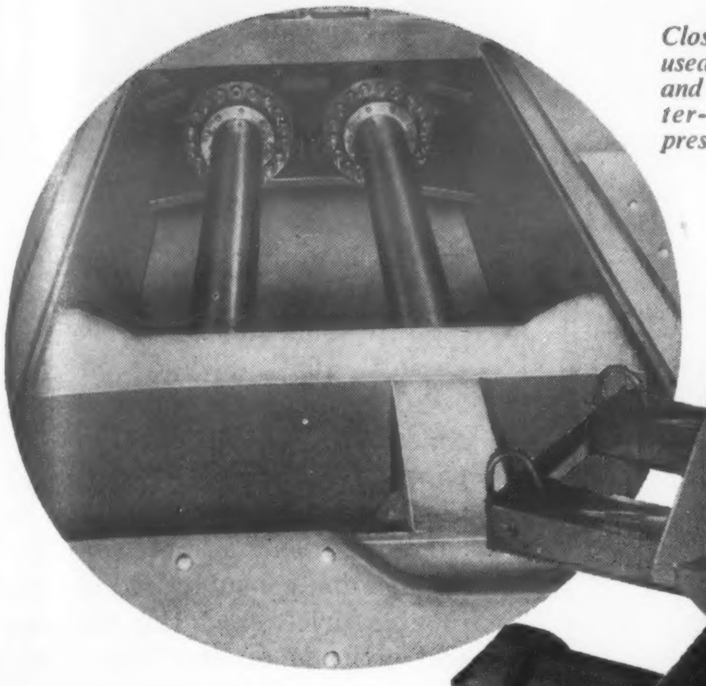
Steel—Bethlehem Steel Corp. is expected to raise its annual steel producing capacity from 20.5 million tons to 23 million tons, according to A. B. Homer, president.

Consumption of iron ore in the United States during the first half of 1957 amounted to 65,339,735 gross tons—an increase of 727,000 tons over production in the similar period last year.

Nylon—Du Pont has lowered prices of all its Zytel nylon molding compounds by approximately 10%. Individual prices depend on quantity and type. Zytel 101, a general purpose compound, has been reduced 15¢ per lb to $1.18, for truckload quantities.

Acrylic fiber—Union Carbide Corp. has increased prices of its Dynel acrylic fibers: natural, increased 5¢ per lb to $1.10; colors, increased 10-20¢ per lb to $1.30-1.40.

Magnesium—Production of primary magnesium ingot reached a peacetime high in the first half of 1957. Total output, all from



Close up of Acipco steel tubes used as hydraulic cylinders and rams in the new Dempster-Balester scrap metal press.

DEMPSTER BALESTER®

New Dempster-Balester "750" features the Auxiliary-Compression Door and Skip-Pan Loader. New, longer charging box handles scrap as large as a complete auto body.

ACIPCO
Centrifugally Spun
STEEL TUBES

Meet us at Booth 1376
Metals Exposition—Nov. 4-8
Chicago

Selected for Newly Developed Press

Dempster Brothers, Inc., of Knoxville, Tennessee, is one of the country's leading manufacturers of baling equipment. They also manufacture equipment in the famous Dempster-Dumpster System of materials handling.

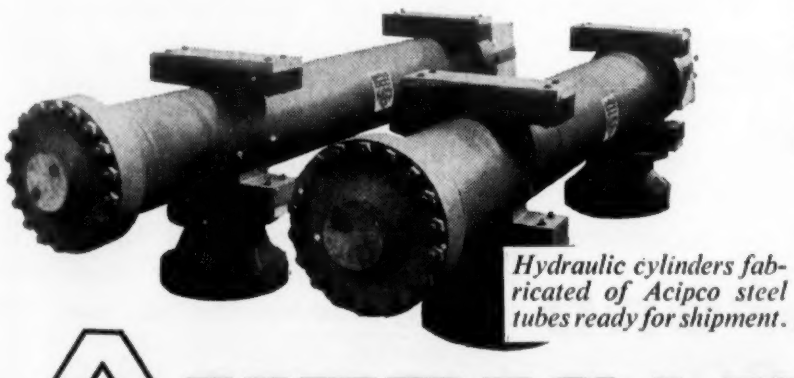
When Dempster Brothers' engineers required powerful hydraulic cylinders for their new "750" Dempster-Balester, they called on Acipco. Working with Dempster Brothers' creative engineering staff, Acipco supplied the two main hydraulic cylinders, completely fabricated and assembled, for this new, more economical press.

The Dempster-Balester main cylinders are examples of the extra advantages you get when you specify Acipco centrifugally spun steel tubes for your application. In addition to getting high quality tubes with the exact physical, metallurgical and chemical properties your application requires, you get the benefits of expert technical assistance and Acipco's combination of complete facilities and manufacturing competence.

If you manufacture or design products requiring tubular steel, your nearest Acipco distributor will be glad to supply information about Acipco steel tube applications in your field.

SIZE RANGE: Lengths up to 16′— longer lengths by welding tubes together. OD's from 2.25″ to 50″; wall thicknesses from .25″ to 4″

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steels; plain carbon grades and special non-standard analyses.



Hydraulic cylinders fabricated of Acipco steel tubes ready for shipment.

DISTRIBUTORS

Austin-Hastings Co., Inc.
226 Binney St.
Cambridge 42, Mass.

Peter A. Frasse and Co., Inc.
17 Grand St.
New York 13, N.Y.

Lyman Tube & Bearings, Ltd.
920 Ste. Sophie Lane
Montreal 3, Canada

Vinson Steel & Aluminum Co.
4606 Singleton Blvd.
Dallas 7, Texas

J. M. Tull Metal & Supply Co.
285 Marietta St., N.W.
Atlanta, Ga.

C. A. Roberts Company
2401 Twenty-fifth Avenue
Franklin Park, Ill.

Strong, Carlisle & Hammond Co.
1392 W. Third St.
Cleveland 13, Ohio

Ducommun Metals & Supply Co.
4890 So. Alameda St.
Los Angeles 54, Calif.

AMERICAN CAST IRON PIPE CO.
ACIPCO
Special Products Division
BIRMINGHAM 2, ALABAMA

For more information, turn to Reader Service card, circle No. 449

Dow Chemical Co.'s two plants in Texas, was 41,267 tons.

Zinc—Consumption of slab zinc during 1957 should go over 900,000 tons, according to the American Zinc Institute. John L. Kimberly, executive vice president, reports that "despite the current unbalance between production and consumption, the drop in zinc prices and the 'wait and see' attitude on the part of zinc consumers, 1957 will end up among the top consumption years in the industry's history."

Cellular Plastics—Production of cellular plastics in 1957 is estimated to reach 29 million pounds, or 55% more than last year's 16 million pounds. According to Dr. Paul G. Roach, chairman of the Cellular Plastics Div of the Society of the Plastics Industry, flexible and rigid vinyl foam production will more than double last year's 3.5 million pounds; production of flexible and rigid urethane foam, which amounted to 4.7 million pounds last year, is also expected to double; and rigid polystyrene foam production, which amounted to 8 million pounds in 1956, is expected to reach 12 million pounds.

Polystyrene—An average price reduction of 5% has been announced by Plax Corp. for its 2-10 mil thick, biaxially oriented polystyrene sheet. The reductions apply to clear materials only.

Granite board—National Starch Products, Inc. is increasing its production capacity of granite board by 50%. According to James Dillon, vice president, growing demand by leading furniture manufacturers necessitated the increase despite the fact that many people in the wood industry consider the particle board market overproduced.

Carbon, graphite—National Carbon Co. has completed its seven year expansion program aimed at adding nearly 100,000 tons to its annual productive capacity.

News OF INDUSTRY

SPI Issues Specifications on PVC Foams

■ Another step forward in the development of plastics foams as predictable engineering materials has been taken with the issuance of three standards by the Cellular Div. of the Society of the Plastics Industry. The standards are:

1. Specifications and methods of test for polyvinyl chloride or vinyl copolymer foams.
2. Methods of test for rigid cellular plastics materials such as styrene, urethane, phenolic and urea foams.
3. Standard methods of chemical analysis of urethane foam raw materials.

Copies of the new standards may be obtained from the Society, 250 Park Ave., New York 17, N. Y. (For further information on foam plastics, see MATERIALS & METHODS, June '56, p 144).

The specifications for vinyl foams include: 1) a definition of terms (including such expressions as open cell, surface and applied skin, mechanically and chemically blown foam, etc.); 2) a definition of acceptable materials and workmanship, and information on color, tolerances on dimensions, packaging and marking, and inspection and rejection; 3) an outline of testing methods arranged according to type of test, apparatus, test specimens, test procedure and calculation of test results; and 4) descriptions of such tests as indentation load deflection, air oven aging, compression set under constant deflection, static fatigue, dynamic flexing and density.

Various grades of vinyl foam are designated by two digit numbers. The first identifies the kind of vinyl foam: 1—uncored, extra firm; 2—cored; and 3—uncored. A second digit is used to indicate the degree of firmness, the softer grades being identified with a lower number and firmer grades with a higher number (see accompanying table).

Three other sets of requirements have not been included in the table. These are: indentation—load deflection (after air oven aging 22 hr at 212 F), should not exceed ± 20% change for all types of vinyl foam; maximum compression set (after 22 hr at 158 F), should not exceed 15% change for all types; and maximum dynamic flexing (after 250,000 cycles), should not exceed 10% for all types.

In order to indicate additional requirements beyond those specified in the table, suffix letters may be added singly or in combination after any grade number. The approved suffix letters and

SPI SPECIFICATIONS FOR VINYL FOAM

Grade ↓	RMA[a] No.	Indentation-Load-Deflection, lb/50 sq in at 25%
UNCORED, FIRM		
V-11......	—	190 ± 60
V-12......	—	360 ± 100
V-13......	—	550 ± 100
V-14......	—	750 ± 100
CORED		
V-20½....	½	6½ ± 3½
V-21......	1	9½ ± 3½
V-21½....	1½	14 ± 4
V-22......	2	17½ ± 4½
V-22½....	2½	23½ ± 5½
V-23......	3	28½ ± 6½
V-23½....	3½	36 ± 7
V-24......	4	42½ ± 7½
V-24½....	4½	51 ± 8
V-25......	5	58½ ± 8½
V-26......	6	76½ ± 9½
V-27......	7	96½ ± 10½
V-28......	8	118½ ± 11½
UNCORED		
V-31......	Extra soft	7½ ± 2½
V-32......	Soft	17½ ± 7½
V-33......	Medium	32½ ± 7½
V-34......	Firm	50 ± 10
V-35......	X Firm	72½ ± 12½
V-36......	XX Firm	105 ± 25

[a]Rubber Manufacturers' Assn.

Metal Show

For details of next month's Metal Show see p 21 of this issue.

their significance are as follows:

Letter	Test Required
C	Weather resistance
D	Load deflection
E	Oil resistance
F	Low temperature
G	Tear resistance
H	Flexing resistance (dynamic)
J	Abrasion resistance
K1	Adhesion to metal (made during molding)
K2	Adhesion, cemented bonds
M	Flame resistance
P	Nonstaining
P1	Compatibility with other materials
R	Resilience
W	Density
Z	Special requirements

According to the specifications, all test methods and values, except flexing resistance and density, are to be arranged between purchaser and supplier.

Annealing Symposium To Be Held At Case

A concentrated, two-day symposium on the annealing of low carbon steel will be held at Case Institute of Technology, Oct 29-30. Top metallurgists from six countries will deliver a dozen papers on annealing processes during five general sessions. The symposium is a cooperative effort on the part of Lee Wilson Engineering Co., Inc. and Case.

Plastics Engineers To Meet This Month

"Polyethylenes—Properties and Uses" is the theme of the Society of Plastics Engineers' one-day Regional Technical Conference to be held Oct 17 at the Hotel Carter, Cleveland.

Some of the papers dealing with polyethylene properties are: "In-

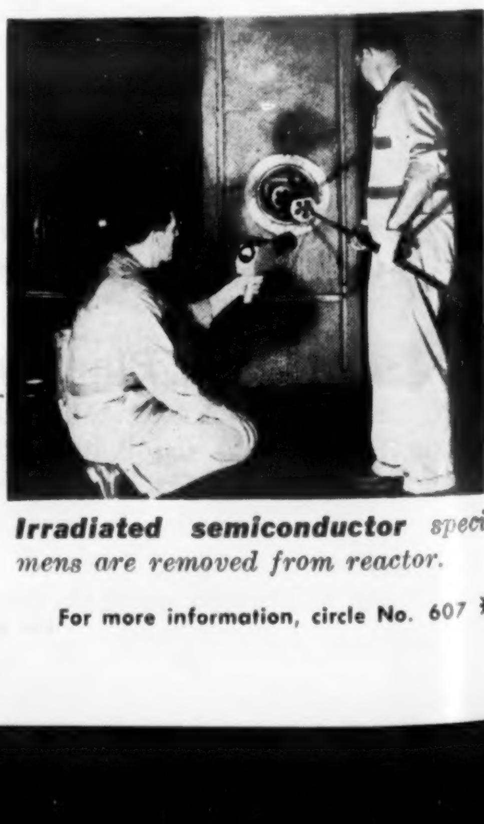
troduction and History of Polyolefins," J. K. Honish, Bakelite Co.; "Low Density Polyethylene," R. M. Campbell, E. I. du Pont de Nemours & Co.; "Medium Density Polyethylene," F.C. Sutro, Jr., Spencer Chemical Co.; and "Linear Polyethylene," G. H. Sollenberger, Koppers Co.

Papers on polyethylene uses are: "Blow Molding," E. E. Mills, Consultant; "Injection Molding," M. Krajcik, Wooster Rubber Co.; "Pipe Extrusion," H. Fackler, American Vulcathene Corp.; and "Film," C. J. B. Thor, Visking Corp.

Advance registrations may be sent to Mr. E. J. Haskins, Zenith Plastics Co., 3901 Superior, Cleveland 14, Ohio. The registration fee is $9.00.

Radiation Studies Made on Semiconductors

Basic experimental and theoretical research aimed at explaining the effects of radiation on semiconductor materials is now in progress at Battelle Memorial Institute. Purpose of the study is to determine which semiconducting materials can be used for the fabrication of electronic components designed to function in relatively intense radiation fields; which will function best; and which will continue to



***Irradiated semiconductor** specimens are removed from reactor.*

function under prolonged irradiation.

Under contract with the Air Research and Development Command's Wright Air Development Center, Battelle will study such materials as aluminum antimonide, gallium arsenide, indium phosphide, cadmium sulfide and cadmium telluride. The effects of both neutron and gamma radiation will be considered.

Minneapolis-Honeywell Enters Plastics Field

Minneapolis-Honeywell Regulator Co. has entered the plastics field with full-scale production of epoxy casting and potting compounds designed especially for use in the electronics industry.

According to James H. Binger, vice president, the move was the

Aluminum extrusions — Shown above is one of four 2300-ton extrusion presses used in Reynolds Metals Co.'s recently completed aluminum fabricating facility. The new plant is said to be capable of producing 2,000,000 lb per month.

According to A. M. Murphy, plant manager, the mill is designed to process aluminum pig and scrap into finished extrusions. The plant is equipped with casting facilities, die manufacturing machine shop, quality inspection department and metallurgical laboratories.

Glidden formula for your profit:

CHANGE METAL POWDER TO PRECISION PARTS

Proved way to cut costs on high-volume production of precision parts: Glidden Powder Metallurgy! That's why Glidden *Resistox*® Metal Powders are so widely used for bearings, friction materials, brushes and other parts.

Leading fabricators like The United States Graphite Company, Division of the Wickes Corporation, Saginaw, Michigan (producers of GRAMIX® sintered metal parts), look to Glidden as a primary source for metal powders.

Resistox Metal Powders meet all standards for purity and consistency. And a much greater resistance to oxidation gives *Resistox* 5 to 10 times the stability of ordinary metal powders!

Perhaps Glidden can help you find a cost-cutting solution to your metal parts production problems.

Write now for more detailed information.

THE GLIDDEN COMPANY

Chemicals - Pigments - Metals Division

Baltimore, Maryland • Collinsville, Illinois • Hammond, Indiana • Scranton, Pa.

For more information, turn to Reader Service card, circle No. 572

result of "eight years of research with epoxy compounds during which notable achievements have been made. The materials are useful," Mr. Binger says, "for encapsulating delicate electronic apparatus to protect it from vibration, moisture, fungus, and other types of damage. They replace tar and wax in the potting of delicate diodes where the part must remain airtight despite wide changes in environmental conditions such as those encountered by today's high speed jet planes."

Outstanding properties of the epoxy compounds include: low thermal coefficient of expansion (approaching that of metal), excellent electrical insulation properties, and high flexural strength (14,000 psi).

ASTM To Set Standards on Nonferrous Metals

According to a report presented at the 60th Annual Meeting of the American Society for Testing Materials, several of the less common nonferrous metals are slated to receive new or revised standards and specifications.

ASTM has already announced that standards for zirconium and lithium will be published in 1958. Active committee groups are being organized to consider standards for beryllium, columbium, tantalum, thorium, uranium and hafnium when the need is indicated. New groups are being formed to look into the need for standardization of molybdenum and tungsten metals and alloys. Specifications for titanium metal and sponge are also being considered.

In addition to the formation of committees on specifications and standards, ASTM is considering the need for symposiums in certain areas. One on solders and soldering has tentatively been

News OF INDUSTRY

planned for 1960, and a committee is investigating the need for a symposium on zirconium, lithium and others of the less common metals.

Engineers

A. F. Sprankle is now technical director and assistant vice president, Vanadium Corp. of America.

Dr. Dimitri Kececioglu has been appointed assistant to the director of mechanical engineering, Allis-Chalmers Industries Group, Allis-Chalmers Mfg. Co.

James S. Sconce has been named technical assistant to management—a new position at Hooker Electrochemical Co.

Jules C. Laegeler is now chief engineer, Frank G. Hough Co.

George P. Diffenderfer has been engaged as engineering planner, Penn Instruments Div., Burgess-Manning Co.

Dr. Hal B. Coats has been promoted to assistant manager, Chemical Plants Div., Blaw-Knox Co.

Roy Dahlstrom, recently appointed director of research, is responsible for the supervision and coordination of activities of all National Lead Co. laboratories.

George W. Wunder has taken over as manager of the newly formed Nuclear Metals Div.

Ralph V. Little, Jr. is now manager of the Product Engineering Dept., Brush Electronics Co., Div. of Clevite Corp.

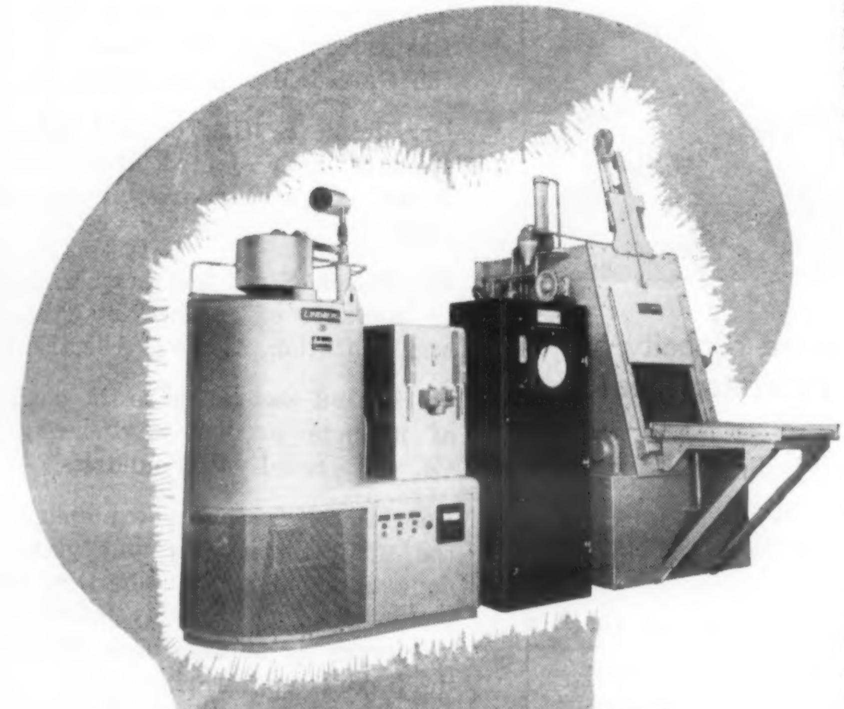
Robert M. Ward has joined Beckman Instruments, Inc. as manager of the Berkeley Div.

Bernard G. E. Stiff is now with United Shoe Machinery Corp. as manager of the atomic power department.

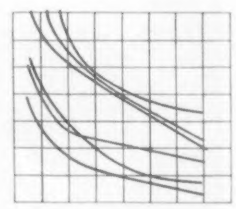
George Brownewell succeeds **Frank Farkash** as process engineer at the Cincinnati plant of Diamond Alkali Co.; Farkash has been advanced to manager of the Jersey City plant. At

What every good metal man should know about CARBONITRIDING

First of all, it is a good idea to know what equipment will do the best carbonitriding job for your specific requirement. And the best way to find this out is to talk over your problems with the people who have consistently developed the methods and equipment for better, more dependable, more economical carbonitriding results. That would be Lindberg.

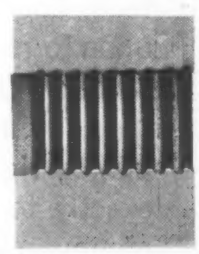


Typical installation of Lindberg Hyen Atmosphere Generator, Lindberg Carbotrol and Lindberg Carbonitriding Furnace.



Let's look at the record. Lindberg's contributions to carbonitriding and carburizing go far beyond just the building of furnaces to do it. It covers the development of controlled atmosphere generators, the creation of dew point equilibrium curves to establish proper atmosphere values for type of steel and temperatures involved and the exclusive Lindberg Carbotrol to maintain these values automatically in production.

Then there is the invention of the "dimple" vertical radiant tube which gave new efficiency and economy to fuel-fired atmosphere furnaces. Lindberg's exclusive CORRTHERM electric heating element made practical the use of electricity in atmosphere furnaces.

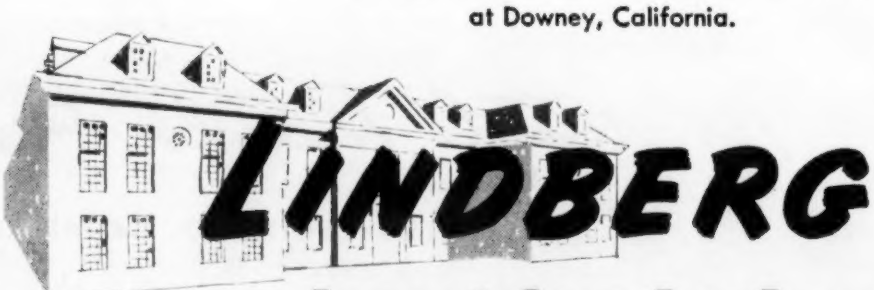


Add to this our record over the years of building a broad variety of carbonitriding and carburizing furnaces, big ones, small ones, manuals, automatics, fuel-fired, electric, and it seems it's just good common sense to bring your heat treating problems to us. Just get in touch with the Lindberg Field Representative in your locality or write:

LINDBERG ENGINEERING COMPANY

2451 West Hubbard St., Chicago 12, Illinois

Los Angeles Plant: 11937 S. Regentview Ave., at Downey, California.



heat for industry

For more information, turn to Reader Service card, circle No. 609

the Diamond silicate plant in Dallas, Texas, **Hanson Roberts** is now assistant plant manager and **Billy J. Miller** staff assistant.

Arthur J. Warner has been appointed director of research for Mycalex Corp. of America.

George H. Durlester has been assigned to the newly created post of general manager, Industrial Engineering, Metal Div., Continental Can Co.

Dr. Irving Kaufman and **Robert F. Reese** are now employees of the Ramo-Wooldridge Corp.; Mr. Kaufman is with the Electronic Research Laboratory and Mr. Reese is with the Guided Missile Research Div.

Dr. Ralph B. G. Yeo and **John B. Adamec** have joined International Nickel Co.'s Research Laboratory staff.

M. Wilson Sims has been assigned as manager of engineering training and education, General Electric Co.

David Duff has moved to the position of manager-product engineering at GE's Everett-Lynn Foundries.

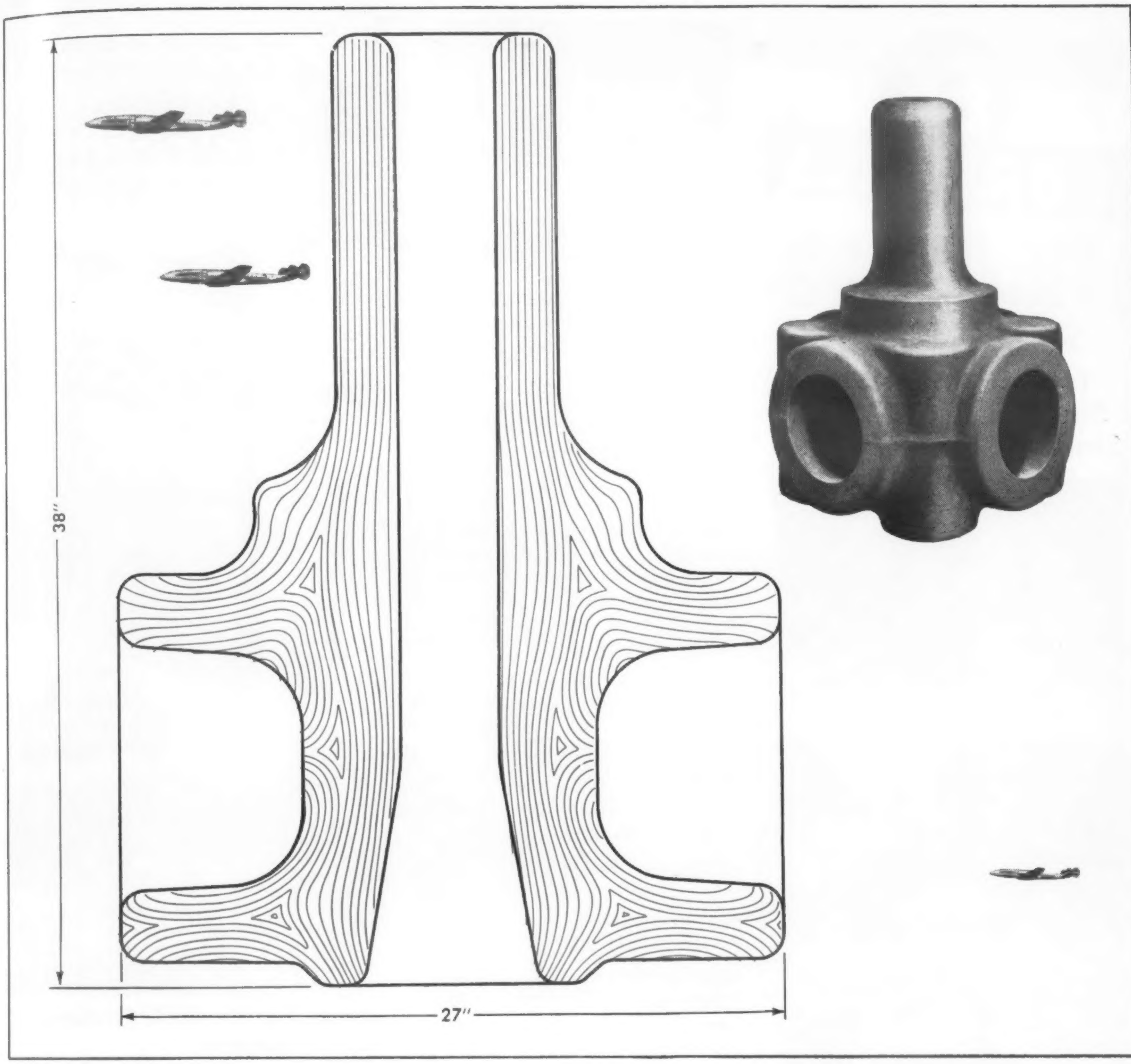
Robert M. Kearns is now manager of the new engineering and planning department at Alloy Tube Div., Carpenter Steel Co. **Barclay Morrison** is in charge of another new section—the product engineering and development department. **James P. Kelleher** is assistant manager and **Wilbur J. Comerford** and **L. Carl Oseland** are product engineers.

Dr. Thornton C. Fry has been appointed vice president and director of Univac Engineering for Remington Rand Div., Sperry Rand Corp.

Reginald G. Schuler has joined Brush Electronic Co. as general engineering manager.

Frederick L. Talcott died at the age of 37 after a brief illness. Mr. Talcott was manager of Westinghouse Electric Corp.'s Refrigerator-Freezer Design Section, and first prize winner in this magazine's 1956-57 awards competition for "Best Use of Materials in Product Design."

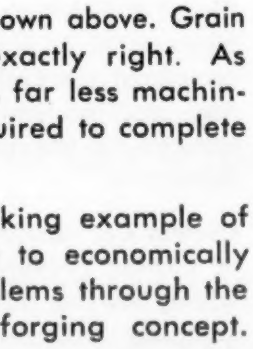
(News of Companies on p 284)



THE SPLIT-DIE FORGING SOLUTION FOR TURBOPROP TORSION

This big Turboprop propeller hub for Curtiss-Wright was turning up a storm in design circles. Specifications called for 2680 lbs. of A.I.S.I. 4355 modified aircraft quality steel to be forged and heat treated to high strength levels, all of which is not unusual except for one thing. The tremendous power transmitted through the neck section of the hub subjected this area to unusual stresses. Grain structure was a prime consideration. This presented a problem because conventional forging methods could not produce the desired grain flow pattern.

The Cameron split-die forging process solved the problem for Curtiss-Wright. In a single pass through Cameron's largest side-ram press, a glowing billet was pierced from six different directions and changed into the near final shape shown above. Grain structures were exactly right. As an added benefit, far less machining time was required to complete the hub.



This hub is a striking example of Cameron's ability to economically solve design problems through the use of a new forging concept. Shapes and sizes formerly considered impossible to forge in closed dies have become routine procedure with this revolutionary technique. If you have a component problem that forces you to accept castings where forging quality is desired, or if conventional forging processes fail to give you the metallurgical quality or economy that you require, write, call or come by . . .

IRON WORKS, Inc.
SPECIAL PRODUCTS DEPARTMENT
P. O. Box 1212, Houston, Texas

For more information, turn to Reader Service card, circle No. 584

News OF INDUSTRY

Companies

American Lithium Institute, Inc., has moved to large quarters at 32 Nassau St., Princeton, N. J. Mail should be addressed to P. O. Box 549, Princeton, N. J.

Minneapolis-Honeywell Regulator Co. has started production of industrial valves at its new Fort Washington, Pa., plant.

Sinclair-Collins Valve Co. and **Valvair Corp.** have completed a plant addition to house general engineering and methods engineering departments, as well as the newly organized development engineering section.

Philco Corp.'s Government and Industrial Div. has established new western development laboratories at Redwood City, Calif.

Sherman Products, Inc. has created a new Spartan Div.

Plastic Age Co.'s new facilities near Saugus, Calif., planned for completion by late summer, will more than double present production.

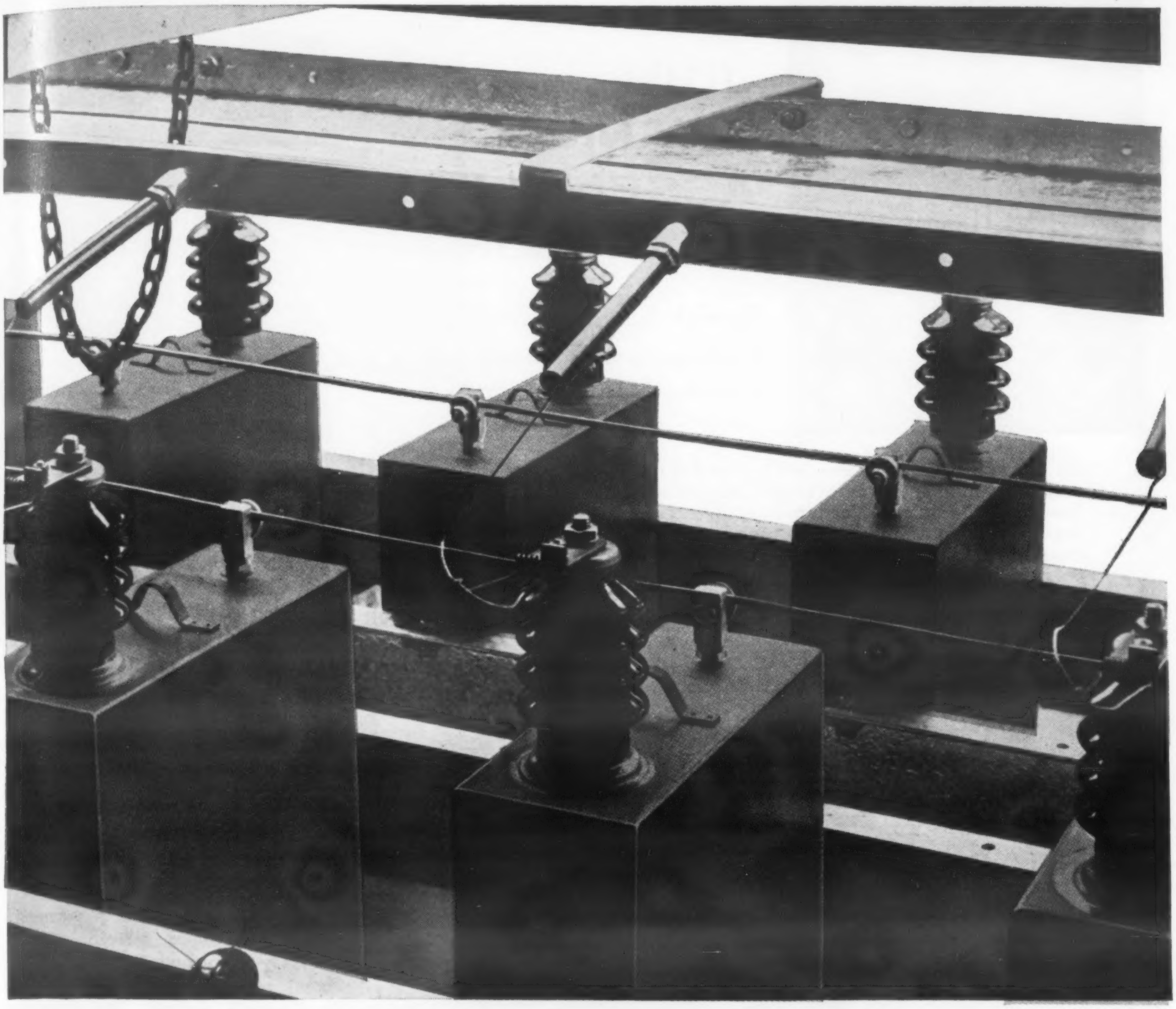
Seymour Mfg. Co. has absorbed its former subsidiary, **Phosphor Bronze Corp.** Seymour will continue to manufacture phosphor bronze.

Servomechanisms, Inc. has started construction of a million dollar plant in Westbury, L. I., N. Y. The plant, scheduled for completion this fall, will provide facilities for design, development and manufacture of subsystems.

Calidyne Co. is constructing a new plant at Woburn, Mass. When completed in early 1958, it will permit centralization of operations now carried on in four different buildings at two different locations.

Skeist & Schwarz Laboratories, Inc., Newark, N. J., is a new firm offering sponsored research, advisory consulting, and economic and marketing surveys to the plastics and textile industries.

Carwin Co. announces the formation of **Carwin Polymer Products, Inc.,** a wholly owned subsidiary. The new company will develop, manufacture



These Tobe Deutschmann Corporation capacitors are protected by a stainless steel case. Carbon steel cases could not withstand for long this type all-weather service.

For more information, turn to Reader Service card, circle No. 416

and market industrial materials and end products researched by the parent company.

Jones & Laughlin Steel Corp. has started production at its new Willimantic Conn., cold finished bar mill.

Superior Tube Co. has authorized construction of a new office building and factory addition at its main plant near Philadelphia.

Miniature Precision Bearings, Inc. has acquired **Split Ballbearing Corp.** through merger; the latter will be operated as the Split Ballbearing Div. of MPB. MPB has also begun construction of a plant addition that will double present manufacturing space.

Amco Research, Inc. is a new **American Metal Co., Ltd.** subsidiary formed to conduct research and development studies for AMC.

Societies

American Welding Society has named Fred L. Plummer, director of engineering, Hammond Iron Works, national secretary to succeed Joseph G. Magrath, retired. Mr. Plummer will maintain his office at the Society's National Headquarters in New York city.

American Society of Mechanical Engineers has named Oscar B. Schier, II, secretary-elect to succeed Clarence E. Davies who is retiring.

Metal Powder Assn. has elected the following officers: president and board chairman — Dr. George A. Roberts, Vanadium Alloys Steel Co.; first vice president—Christopher L. Snyder, General Ceramics Corp.; second vice president—Carl G. Johnson, Presmet Corp.; chairman, Powder Producers Div.—E. H. Klein, New Jersey Zinc Co.; chairman, Ferrites Div.—C. L. Snyder, General Ceramics Corp.; chairman, Iron Powder Core Div. — D. L. Almquist, Stackpole Carbon Co.; executive secretary and treasurer—Kempton H. Roll. Directors are: P. Ulf Gummeson, Hoeganaes Sponge Iron Corp.; C. E. Hanson, National-U.S. Radiator Corp.; J. K. Nyburg, Re-

News OF INDUSTRY

public Steel Corp.; C. Allen, American Metal Co.; G. J. Comstock, Easton Metal Powder Co.; V. T. Price, Pyron Corp.; T. L. Tobinson, Powdercraft Corp.; J. M. Copeland, International Business Machines Corp.; B. I. Horton, Pitney-Bowes, Inc.; R. C. Burgess, Burgess-Norton Mfg. Co.; J. Mikitka, Kwikset Powdered Metal Products; H. R. Delaney, Aerovox Corp.; D. L. Andrews, Stackpole Carbon Co.; W. W. Garstang, Allen-Bradley Co.; R. D. Ponemon, Pyroferric Co.; S. Lowenberg, National Moldite Co.; C. S. Batchelor, Raybestos-Manhattan, Inc.; and E. J. Lewis, Federal-Mogul Corp.

At its recent annual meeting MPA decentralized its organization by giving greater autonomy to the cooperating divisions.

Solid Carbide Tool Institute has been organized to establish uniform physical and nomenclature standards for solid carbide cutting tools and the raw materials used to make the tools. Further information may be obtained by writing to the Institute at 295 Madison Ave., New York 7.

Alloy Casting Institute has elected the following officers: president—F. M. Fahrenwald, Fahralloy Co.; vice president—Paul L. McCulloch, Jr., Electro-Alloys Div., American Brake Shoe Co.; executive vice president and treasurer—E. A. Schoefer. Frank Kiper, Michigan-Standard Alloy Casting Co., and J. B. Dear, Duraloy Co., were elected to the board of directors.

International Council of Societies of Industrial Designers has named as president Peter Muller-Munk, a fellow and past president of the American Society of Industrial Designers. Other officers are: first vice president—Mischa Black of London; second vice president—Enrico Peressatti of Milan; and secretary-treasurer—Pierre Vago of Paris.

ICSID is now a permanent organization established in order to set international professional standards of performance and business conduct and to serve as a source of interchange for significant trends, ideas and activities in the design and technical fields.

(News of Meetings on p 290)

Ameri-
mstock,
V. T.
binson,
peland,
achines
Bowes,
Norton
t Pow-
elaney,
drews,
. Gar-
. Pone-
nberg,
Batche-
.; and
orp.
MPA
by giv-
he co-

s been
physi-
ds for
d the
tools.
tained
t 295

lected
ent —
Co.;
alloch,
erican
presi-
oefer.
rd Al-
Dur-
rd of

ies of
ed as
a fel-
meri-
ners.
ident
econd
ti of
rer—

rgan-
set
dards
duct
nter-
deas
and

290)

83 ➤

Meetings

NATIONAL ELECTRONICS CONFERENCE, 13th annual conference. Chicago. Oct 7-9.

AUDIO ENGINEERING SOCIETY, 1957 convention. New York City. Oct 8-12.

GRAY IRON FOUNDERS' SOCIETY, annual meeting. Chicago. Oct 9-11.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, annual meeting. San Diego, Calif. Oct 9-11.

SOCIETY OF THE PLASTICS INDUSTRY, INC., 13th annual New England section conference. Portsmouth, N. H. Oct 10-11.

PRESSED METAL INSTITUTE annual meeting. Castle Harbour, Bermuda. Oct 13-17.

SOCIETY OF THE PLASTICS INDUSTRY, INC., Cellular Plastics Div. conference. New York City. Oct 16.

AMERICAN SOCIETY FOR QUALITY CONTROL, 11th annual conference, New England sections. Oct 16-18.

MAGNESIUM ASSN., annual convention. New York City. Oct 17-18.

AMERICAN SOCIETY OF INDUSTRIAL DESIGNERS, annual national convention. Ojai, Calif. Oct 17-20.

NATIONAL ASSN. OF CORROSION ENGINEERS, seventh annual western regional conference. San Diego, Calif. Oct 22-24.

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT, 25th annual meeting. New York City. Oct 24-25.

ATOMIC INDUSTRIAL FORUM, fourth annual conference. New York City. Oct 28-30.

AMERICAN NUCLEAR SOCIETY, 2nd fall meeting. New York City. Oct 28-30.

1957 TRADE FAIR OF THE ATOMIC INDUSTRY. New York Coliseum. Oct 28-31.

FEDERATION OF PAINT AND VARNISH PRODUCTION CLUBS, 35th annual meeting. Philadelphia, Oct 30-Nov 2.

2ND WORLD METALLURGICAL CONGRESS, American Society for Metals in conjunction with 39th annual National Metal Exposition. Chicago. Nov 2-8.

INSTITUTE OF METALS DIV., American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., annual fall meeting. Chicago. Nov 4-7.

SOCIETY OF PLASTICS ENGINEERS, regional technical conference, Southern California section. Los Angeles. Nov 11.

BOOKS & REPORTS

Books

Investment Casting Engineering and Design Manual. *Investment Casting Institute, Chicago. 1957. Paper, 8½ by 11 in., 50 pp. Price $5.00*

This book gives complete and authoritative information on the investment casting process, showing both the advantages and limitations of the process. Of particular interest is a design section which presents rules governing investment casting design, dimensional tolerances, shapes, surface finish, radii, length, angles, roundness, concentricity, flatness, threads and contours. The manual outlines both the lost wax and frozen mercury processes and features 10 pages of case histories covering investment cast parts.

Standard Metallizing Symbols (Tentative). *American Welding Society, New York. 1957. Paper, 6 by 9 in., 10 pp. Price $1.00*

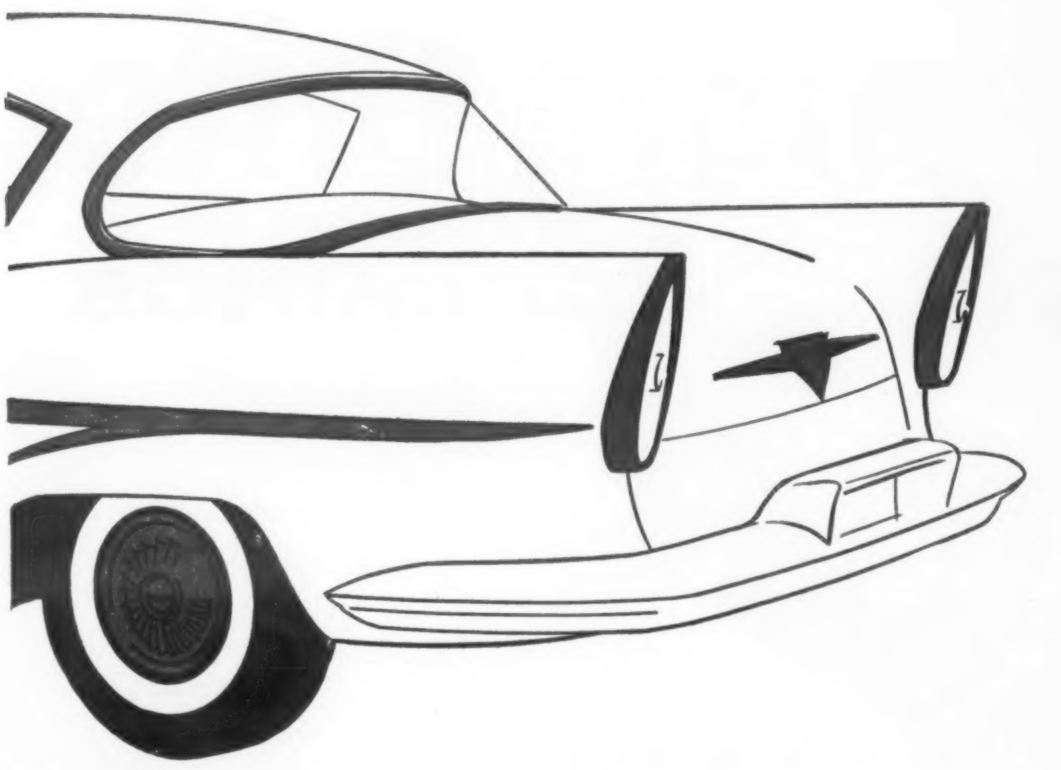
The use of symbols for standard industrial practices gives a clearer interpretation of requirements shown on a drawing than does the use of long, written instructions. With publication of Standard Metallizing Symbols it is now possible to specify metallizing requirements simply and accurately. Full details are given for developing metallizing symbols to specify such operations as surface preparation, extent of metallizing, thickness of coating and method of finishing.

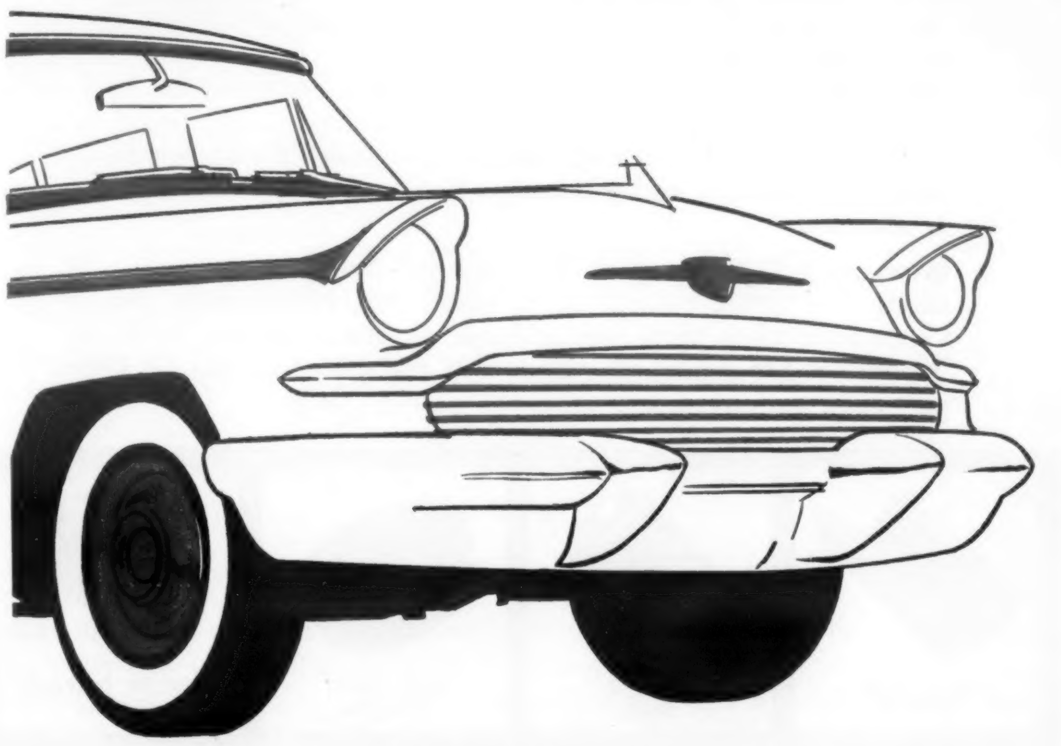
Cast Metals Handbook: 4th Edition. *American Foundrymen's Society Inc., Des Plaines, Ill., 1957. Cloth, 8½ by 11½ in., 321 pp. Price $10.00*

Divided into six sections, this book contains up-to-date information on the properties, uses and manufacture of cast metals. The first section contains general information on cast metals and a cross index of equivalent ferrous and nonferrous casting alloy specifications. Sections 2, 3, 4, 5 and 6 give properties, specifications, chemical composition, uses and method of manufacture of gray,

STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on car sales and resales





Stainless steel styling is easiest of all to sell! Body and window mouldings, wheel covers, grilles, door handles and even roofs are stainless steel this year!

Nothing sells and satisfies like quality. Stainless steel provides proof of quality in a way the buying public can *easily* understand.

Consumers know from experience that stainless steel means rust resistance . . . strength . . . freedom from scratches and dents. They *know* it stays bright without polishing.

That's why stainless steel carries so much selling power in the showroom and even more on the used car lot.

For more facts about stainless steel see your supplier or write: ELECTRO METALLURGICAL COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

METALS DO MORE ALL THE TIME ...THANKS TO ALLOYS

Electromet

FERRO-ALLOYS AND METALS

UNION CARBIDE

For more information, turn to Reader Service card, circle No. 420

BOOKS & REPORTS

white, malleable, and nodular cast irons, as well as steel castings and nonferrous alloys.

Manufacturing Processes: 4th Edition. *Myron L. Begeman. John Wiley & Sons, Inc., New York. 1957. Cloth, 6 by 9 in., 618 pp. Price $8.00*

Designed for engineering students, this book outlines the advantages and limitations of ferrous, nonferrous and nonmetallic materials that are commonly used in industry. The book provides a comprehensive survey of such manufacturing processes as powder metallurgy; hot and cold working of metals; electroforming and coating; and cutting, drilling, milling, sawing and welding of metal. Cutting speeds for high speed tools, wood, cast iron, brass and stainless steel are given in tabular form.

Glass Reinforced Plastics: 2nd Edition. *Edited by Phillip Morgan. Philosophical Library, Inc., New York, 1957. Cloth, 6 by 9½ in., 291 pp. Price $15.00*

The 18 chapters in this revised second edition contain 61 diagrams, 50 photographs and numerous tables to illustrate the various properties and uses of glass-reinforced plastics. Although all important resins such as phenolic, silicone, melamine, furane and epoxy are discussed, particular attention is given to polyester resins since glass reinforcement is most widely used with this resin.

The book outlines the use of glass-reinforced plastics in the aircraft, marine, electrical, automotive and chemical industries. In addition, a description of several techniques used in fabricating glass-reinforced plastics are given.

Mr. Morgan is editor of *British Plastics* magazine.

Engineering Properties and Applications of Plastics. *Gilbert F. Kinney. John Wiley & Sons, Inc., New York, 1957. Cloth, 6 by 9 in., 285 pp. Price $6.95.*

Dr. Kinney in the opening chapter of this book says, "Plastics are the wonder engineering materials of the modern age, provided that they are properly employed." In order to help design engineers better understand these materials the author not only outlines the desirable properties of plastics but also lists their natural limitations. In separate chapters the author describes the uses and physical and chemical characteristics of such plastics as polyethylene, poly-

For more information, circle No. 400 ➤

BOOKS & REPORTS

vinyl chloride, polystyrene, acrylic, silicone, phenolic, polyester and epoxy resins. Other chapters contain information on methods of fabrication and mechanical, electrical, optical and thermal properties of plastics.

Reports

Cadmium-tin plates A STUDY OF CADMIUM-TIN AND ZINC-TIN ALLOY ELECTRODEPOSITS. *B. Cohen, Wright Air Development Center. Sept '54. 44 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $1.25 (PB 121808)*

Tests conducted on cadmium-tin coatings show the coating has excellent resistance to salt spray, jet fuels, high temperature synthetic oils and organic acid vapors. The coating has very little embrittling effect on steel as compared to cadmium plated from a cyanide solution. Zinc-tin alloy coatings were inferior to cadmium coatings in all tests.

Forming titanium FORMING OF TITANIUM AND TITANIUM ALLOYS: PART I. *Battelle Memorial Institute. May '57. 247 pp. Available from Office of Techanical Services, Dept. of Commerce, Wash. 25, D. C. Price $6.25 (PB 121917)*

Describes 13 major methods of forming titanium sheet. Information on heating and stress relieving, formability tests, and equipment used in forming titanium sheet. Discusses a number of forming problems suggested by industry engineers.

Hard surfacing TENTATIVE SPECIFICATION FOR SURFACING WELDING RODS AND ELECTRODES. *July '56. 26 pp. Available from American Welding Society, 33 W. 39th St., New York 18. Price 40¢ (AWS A5.13)*

Forty-five classifications of filler metal are established by this specification, including many of the commonly used surfacing materials such as high speed steels, austenitic manganese steels, austenitic high chromium irons, and cobalt-base, copper-base and nickel-chromium-boron filler metals. Gives data on hardness, impact resistance, corrosion resistance and machinability.

Impact behavior A STUDY OF THE IMPACT BEHAVIOR OF HIGH TEMPERATURE MATERIALS. *H. B. Probst and H. T. McHenry. Mar '57. 23 pp. Available from National Advisory*

BOOKS & REPORTS

Committee for Aeronautics, 1512 H St., NW, Wash. 25, D. C. (TN 3894)

Discusses the impact behavior of titanium carbide-base cermets and high temperature alloys from room temperature to 1750 F. Also discusses the effects of binder composition, microstructure, temperature and stress concentration on the impact strength of cermets.

Hardness vs strength THE RELATIONSHIP OF HARDNESS MEASUREMENTS TO THE TENSILE AND COMPRESSION FLOW CURVES. *R. E. Lenhart, General Electric Research Laboratory. June '55. 14 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price 50¢ (PB 121144)*

Results of experimentation with magnesium-aluminum alloys show that the approximation of a uniaxial tensile stress flow curve from hardness measurements is possible by utilizing empirical conversion constants. Agreement of the tensile and hardness testing methods is possible with such metals as aluminum, copper and steel.

Radome core material LOADED DIELECTRIC FOAMS. *G. E. Niles, Emerson and Cuming, Inc. Dec '56. 51 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. Price $1.50 (PB 121897)*

Discusses the use of isocyanate resinous foams loaded with aluminum microflakes for use in sandwich radome construction. Electrical properties of the loaded isocyanate foams compare favorably with those of other radome core materials.

High temperature sealant HIGH TEMPERATURE RESISTANT SEALANT MATERIALS. *L. C. Boller and others, Coast Pro-Seal and Mfg. Co. Dec '56. 67 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. Price $1.75 (PB 121911)*

Outlines the development of fuel tank sealant compounds to withstand fuel vapor temperatures of 540 F and liquid fuel temperatures of 380 F for a limited period of time. Various types of butadiene-acrylonitrile rubbers and phenolic resins were evaluated. A compound unaffected by JP-5 jet fuel at high temperatures was developed.

advertising sales staff

Materials in Design Engineering • 430 Park Ave., New York 22, N. Y. • MUrray Hill 8-8600

M. RANDOLPH LONG • *Advertising Sales Manager*

NEW YORK:
A. STEWART HALE — *District Manager*
GEORGE L. FOX, JR. — *District Manager*
BEVIN SMITH — *District Manager*

CHICAGO:
111 W. Washington St., RAndolph 6-8497
A. E. FOUNTAIN — *District Manager*
PHILIP O'KEEFE — *District Manager*

CLEVELAND:
815 Superior Ave. N.E., PRospect 1-5583
H. CHARLES ESGAR — *District Manager*
D. W. HUETTNER — *District Manager*

SAN FRANCISCO: 625 Market St. YUkon 6-0647
ROY M. McDONALD — *District Manager*

LOS ANGELES:
3727 West 6th St., DUnkirk 7-5391
C. J. CRABB, JR. — *District Manager*

SEATTLE: 1008 Western Ave., ELliott 3766
HARRY ABNEY — *District Manager*

TULSA: 2010 South Utica, RIverside 3-1981
TED R. TRAUTMANN — *District Manager*

HOUSTON: 3217 Montrose Blvd., JAckson 9-6711
FRANK N. VICKREY — *District Manager*

DENVER:
Colorado Nat'l Bank Bldg., KEystone 4-4669
ROBERT H. HEIDERSBACH — *District Manager*

THE LAST WORD

by **H. R. Clauser,** *Editor*

Titanium Running Out Our Ears

The song title, "What a Difference a Day Makes," can be applied almost literally to the titanium supply situation. A few months back, when Jack Everhart, our Technical Editor, began gathering information for the Titanium Manual, which appears in this issue (p 149), defense planners were asking for more production. Today about one-half of our titanium production capacity is idle.

The titanium boom has backfired, momentarily at least, chiefly because of aircraft cutbacks. But another reason is that nondefense markets have not developed as quickly as anticipated. Perhaps our Titanium Manual will help stimulate more industrial applications.

From Jack's experience in preparing this manual, it would seem that the government's policy on encouraging nondefense applications of titanium is as vacillating as the supply picture. Several years ago Army Ordnance flew a plane-load of editors (including myself) to Watertown Arsenal to attend a symposium organized to stimulate wider civilian use of titanium. They were obviously eager for our help in publicizing the metal. Now, when wider industrial use of titanium is even more important, apparently they no longer care, judging by the treatment Watertown Arsenal gave the titanium manuscript that was sent to them for review. It came back to us with a curt reply saying they were too "busily occupied on special projects" to review the article.

The Unfinished Story of a Name

Most of the many different forms of metals and nonmetallics have definite names. Not so with parts made from metal powders. They are called metal powder parts, powdered metal parts, sinterings, powder metallurgy parts, powder pressings—just to mention a few.

The industry has been struggling for several years now to come up with a name for their products that will please everyone. There have been committee meetings, surveys, reports, innumerable discussions and arguments on the subject, but the end is not yet in sight.

"Sinterings" had the inside track for awhile when it was favored by the ASTM powder metallurgy committee and when a survey by the Metal Powder Assn. showed no overwhelming preference for any one name. But the parts fabricators are opposed to the term; and just recently the new Powder Metallurgy Parts Manufacturers Assn. has officially come out for the name "powder metallurgy parts."

After about a half minute of deliberation I have come up with a compromise name designed to please everyone. I offer it to the industry free of charge. The name is "pow-met-press-sints." On second thought I believe a shorter version of this would be better. So let's shorten it to "pome-presins." I will leave it up to the various committees to agree on where the accent should be placed.

No One Ever Told Him

Every once in awhile we come across an incident that makes us realize how little some engineers really know about materials. Recently the building department of a large city ceased approving certain sizes of aluminum awnings because the word aluminum does not appear in the code. The chief engineer of the department also was quoted as saying, "We don't know the strength of aluminum." To those of us who think of aluminum as a common engineering metal it comes as a considerable shock to realize that aluminum is still a metal of mystery to some engineers.

Brainstorming Attendance

Getting people out to local technical society meetings seems to be a universal problem. Here's a tip that might be of interest to all you local section officers. Try brainstorming for ideas on ways to increase attendance. The Chicago chapter of the American Society for Metals brainstormed the problem for only five minutes and produced 20 ideas.